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BUCKINGHAM PALACE — THE GRAND HALL.
An example of indirect lighting carried out by means of architectural lamps concealed in troughs designed to appear as part of the existing cornice moulding.

G.E.C. Journal

VOL. VI. FEBRUARY, 1935. No. 1.

Electrical Progress and Development During 1934.

By H. W. RICHARDSON, B.Sc., M.I.E.E.
Editor of the G.E.C. Journal.

ELECTRICAL science and industry find no opportunities for marking time; their activities are continuous. This statement is axiomatic, for the solution of one group of problems serves but to create subjects for new fields of investigation; contemporary industries call insistently for the aid of electricity in the development of economic manufacturing processes, while the community at large grows ever more accustomed to accepting "the electrical idea" as indispensable to its well-being. Even during years when world conditions dictate reduced production, there can be no slackening of effort. Such periods are occupied with the search for new and improved methods, so that the subsequent broadening of markets may be met by an industry keenly alive to the most modern conditions.

The events of recent years bear testimony to these contentions, for the worsening of trade conditions in no sense impaired electrical progress and development. Therefore, during 1934 the industry has been quick to respond to the increased demand for new and highly efficient equipment.

It is particularly gratifying to be able to record that the workshops devoted to the heavier types of electrical plant give evidence of the growing trade revival. This branch of electrical enterprise had experienced the full effects of the slump, and the fact that now many large power units are being built affords the best possible indication for future prosperity.

There has been no outstanding discovery or invention in the past year which calls for special comment, but the volume of work which has been successfully accomplished contributes a full share to the sum of electrical knowledge.

The Research Laboratories at Wembley have been engaged in a wide variety of activities, to which brief reference follows.

OSIRA STREETLIGHTING LAMP.

Until recently the "Osira" street lighting lamp has been available only in the original 400 watt size. Development work on other sizes has been proceeding, and last September a 250 watt "Osira" lamp was placed on the market.

A colour modified 400 watt lamp has been produced in which the percentage of red light has been increased somewhat by the addition of cadmium and zinc. The increase of red radiation is, however, accompanied by a marked drop in efficiency, this being inevitable in any attempt to add red light to a mercury lamp.

Improvements continue to be made in the general performance of the lamps, the initial light output both of the 400 and 250 watt sizes having been increased as shown in the following table.

Standard Watts.	Old (Lumens).	New (Lumens).
400	16,000	17,000
250	8,750	9,000

Another recent notable advance has been in connection with the lumen maintenance throughout life. The dark films which gradually formed on the inner surface of the discharge tube during life have been very largely eliminated, with a consequent improvement in the lumen maintenance.

The table below shows the efficiencies which may now be expected.

Standard Watts.	Initial Lumens per Watt.	Average Lumens per Watt up to 1,500 hours.	Lumens per Watt at 1,500 hours.
400	42.5	35	33
250	36	31	29
400 (colour corrected).	35	29	27

OSIRA FLOODLIGHTING TUBES.

Considerable improvements in the overall efficiencies of hot cathode floodlighting tubes have recently been made, and these new tubes are now in production. The efficiency of the red tubes has been increased from 8.2 to 9.5 lumens per watt; in the case of the mercury tubes a much greater improvement has been effected. The figure for the light blue and light green tubes is now

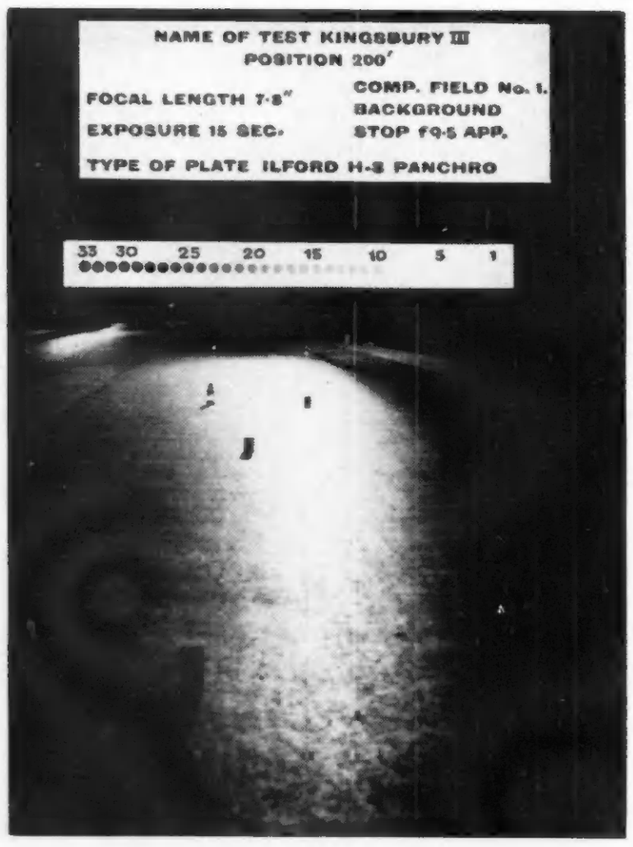


Fig. 1.—Determination of road reflection properties. A print from a test negative obtained at a distance of 200 ft. from the post.

12.0 lumens per watt, compared with the older value of about 8.5 and the efficiency of the dark green tube has been increased from 6.0 lumens per watt to 9.0 lumens per watt. In addition, a new colour, dark blue, has been added to the series already available. The efficiency in this case is not so high as for the other tubes on account of the blue glass, but it is well in advance of that which may be obtained by the use of tungsten lamps and colour screens. The overall efficiency is 4.2 lumens per watt for the dark blue tube and the overall wattage 320.

The most recent development is a yellow tube, having a rating of 100 watts only, but a high light output on account of its overall efficiency reaching 38 lumens per watt. A reflector and housing have been designed for this lamp, and the first installations have shown that good floodlighting results can be obtained with this yellow light for a comparatively small expenditure of power.

COLD CATHODE DISCHARGE TUBES.

An improved method of making red ripple tubes has been developed, and this attractive form of discharge is now commercially available. A number of these tubes were in use during the recent autumn illuminations at Blackpool.

The factors influencing the blackening which sometimes occurs in standard blue tubes have been elucidated, with a corresponding improvement in performance of these tubes.

GLASS AND REFRACTORIES.

One member of a series of new "hard" glasses has been standardised for Osira discharge lamps, and is now made on a fairly extensive scale. Two of the main characteristics are very high softening temperature and high electrical resistance.

New glasses have also been developed for the sodium vapour discharge lamp, for architectural striplites and for electric lighting fittings.

Successful experiments have been made on the production of insulators from highly refractory materials such as pure magnesia and alumina. These insulators are now being manufactured for use in valves.

REFLECTION PROPERTIES OF ROAD SURFACES.

An investigation of considerable importance to street lighting is in progress. The reflection properties of road surfaces are being examined by a photographic method in order to determine the way in which they affect the brightness distribution of the road surface (figs. 1, 2 and 3). The investigation is complete for a two-coat asphalt road surface[1] and the data obtained enable lighting installations to be planned in such a way as to obtain high values of road brightness with a maximum of uniformity. It is expected that the work will enable road surfaces to be classified in order of merit and will lead to the production of an optimum light distribution for street lighting units.

ARC LAMP CARBONS.

New types of cinema arc lamp carbons have been developed, both of the hard-core and soft-core variety.

Testing equipment has been installed which allows of carbons being burned under conditions comparable with those in a cinema. The equipment includes the principal types of lamp in use at the present time, with arrangements for measuring the intensity and uniformity of the light as received on the screen. Apparatus has also been devised

(1) J. M. Waldram, Illuminating Engineer, October and November, 1934.

for recording the amount of flicker in the arc during burning.

The subject of testing has been dealt with fully during the year in an article in this Journal.

HETEROCHROMATIC PHOTOMETRY.

With the development of electric discharge lamps it became necessary to investigate further the problems connected with the photometry of coloured light sources. A very large programme has therefore been carried out during the last two years, in order to establish methods of photometering electric discharge lamps. This work has been fully described in this Journal[2].

COMMERCIAL PHOTOMETRY OF ELECTRIC DISCHARGE LAMPS.

The photometry of electric discharge lamps at commercial speeds not only makes use of the work referred to in the last paragraph, but requires special circuit arrangements due to the characteristics of the lamps. The establishment of working standards of light in these lamps and the experience gained during the last four years with photoelectric methods of measuring tungsten filament lamps at commercial speeds, has made possible the design and construction of an integrating photoelectric photometer with special circuit arrangements to

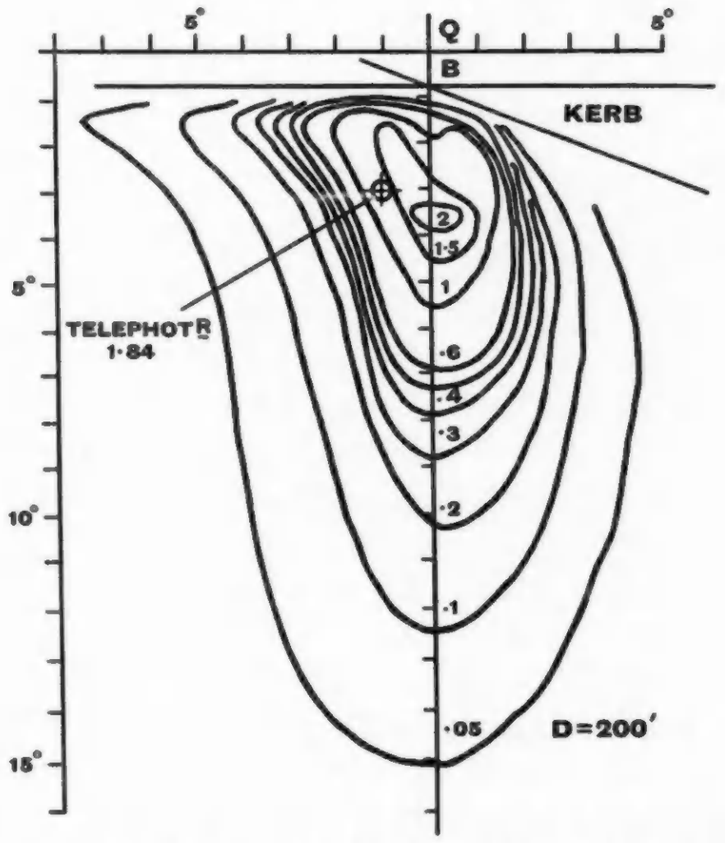


Fig. 2.—Distribution of brightness deduced from fig. 1.

enable electric discharge lamps to be measured at commercial speeds. A full description of these recent developments in photoelectric photometry is in course of publication.

HOTPLATES.

(*a*) *Loadings.*

As a result of the investigation which has been proceeding during the past few years into the design and performance of embedded type hotplates, it has been found possible substantially to increase loadings. During the past year there has been put on the market an 8 inch diameter hotplate, loaded to 2,250 watts, an increase of 25 per cent over the previous loading (1,800 watts).

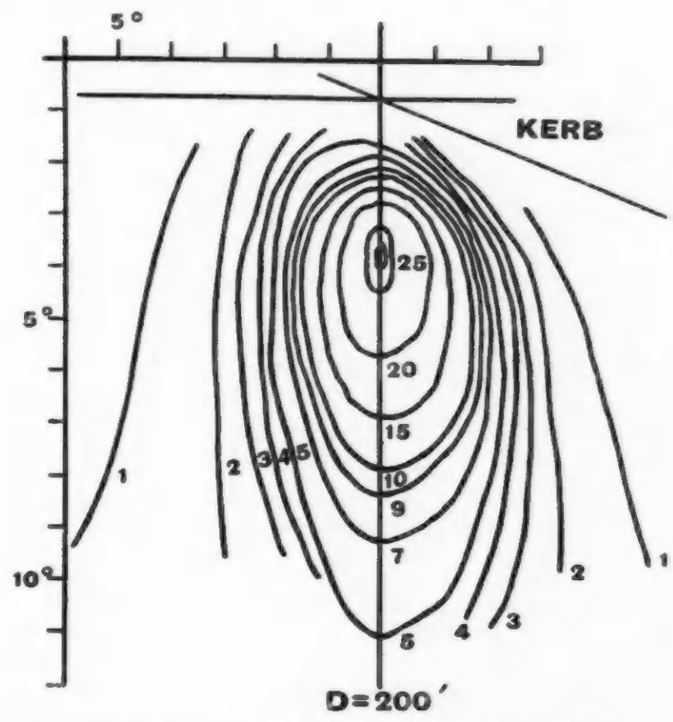


Fig. 3.—Distribution of reflectivity deduced from fig. 1.

The hotplate casting has been thoroughly investigated and completely redesigned, and the grooves increased considerably in length. Consequently, in spite of the higher loading, the energy dissipation per unit area of wire surface has been enormously reduced, and the current density in the wire is now actually lower than in the 1,800 watt hotplate. At the same time the distribution of the coil over the hotplate top has been so arranged that this now operates at a much more uniform temperature than was previously the case, while the extra energy dissipation has been achieved with but very little increase in the maximum temperature of the casting.

(*b*) *Simmering.*

With the increase in hotplate loadings it has become increasingly difficult to provide satisfactory simmering conditions at the "low" loading given by the normal three-heat switch (*i.e.*, one quarter of full load). To overcome this difficulty an external resistance has been added, and the switching so arranged that it can be introduced into the circuit in series with the hotplate windings when the three-heat switch is in the "low" position. The external resistance is normally short-circuited by a separate switch mounted behind the switch panel. When the special low loading is required, the three-heat switch is set to "low" and the short-circuiting switch is opened by depressing a button situated immediately above the knob of the three-heat switch. An interlock is provided between the two switches to ensure :

1. That the button cannot be depressed when the three-heat switch is in any but the "low" position.

(2) G.E.C. Journal, Vol. V., No. 3, p. 125.

2. Movement of the knob of the three-heat switch from the "low" position towards either the "off" or the "medium" position automatically releases the push button.

STORAGE COOKERS.

Two new storage cookers, both of which give a substantially improved performance, have been developed. The first one is similar in general principles to an earlier model, but modifications to the block construction have made it possible for the temperature of the lower surface of the block, which is used for grilling and oven heating, to be practically independent of that of the top surface, which is used for boiling, etc. Consequently, grilling and toasting are now possible at all times at which they can reasonably be required, and the variations in oven preheating time, which were experienced with the earlier model, have been largely eliminated. The exceptionally rapid boiling which is associated with this type of cooker has been retained. In addition, it has been found possible to reduce the energy consumption by 10 per cent without in any way detracting from the cooking capacity.

Fig. 4.—Improved form of storage cooker.

The second cooker, which may be regarded as a semi-storage cooker, employs the storage principles in the hotplate only. The oven and grill are heated by elements of conventional type, although the switching arrangements are unusual and exceptionally simple. The maximum loading of this cooker is 1,950 watts, and the amount of work that can be done on it is, for all practical purposes, no more limited than it is in a cooker of conventional type and of the same size. During the greater part of the day and night the rate of energy consumption is steady at 250 watts, and the total energy consumption when cooking for six people, is about 7.5 units per day.

THERMOSTATS.

An addition to the range of thermostats which has been introduced this year is an instrument specially designed for the control of domestic ovens.

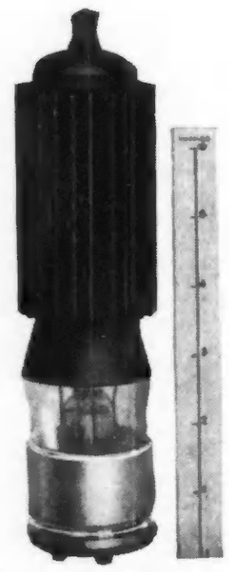


Fig. 5.—Air-cooled anode valve, type E. 472.

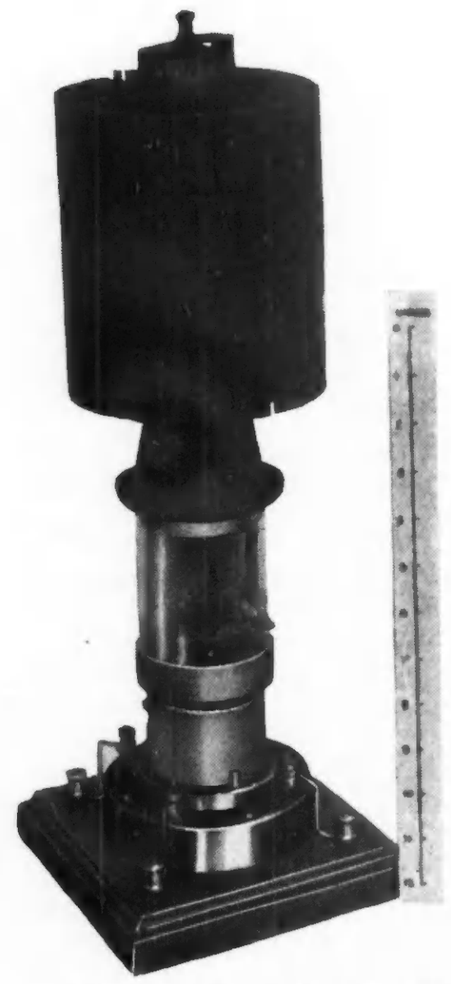


Fig. 6.—Air-cooled anode screen grid valve, type E. 530.

AIR COOLED ANODE TRANSMITTING VALVES.

A new range of medium power transmitting valves is now in course of development. These have air cooled copper anodes as part of the envelope and in the larger sizes blackened copper fins are fitted to assist in heat dissipation. All the dead loss ratings given below may be increased considerably by low pressure air jets to aid the convection. All the types made have shown an improved short wave and ultra-short wave performance compared with their glass valve counterparts, some giving a conversion efficiency of 60 per cent at 6 metres.

Among the types so far developed, the largest (E477) has a bright emitting tungsten filament and can dissipate 800 watts continuously at the anode. It is capable of operation down to 4 metres. A screen grid valve (E530) having a dead loss rating of 400 watts has also been developed and is shown at fig. 6. It has a thoriated tungsten filament and the operating anode voltage is 4,000 volts at wavelengths above 200 metres. Valves having oxide coated cathodes have also been developed in this construction and the largest type (E472) is shown in the photograph (fig. 5). The dead loss rating is

75 watts and the maximum anode voltage 1,500 volts. The E472 is capable of operating at very short wavelengths with reduced anode voltage.

Operation trials on all types are in progress, and so far have proved satisfactory. Other types are being developed.

PHOTOCELLS.

A new demand has arisen for very small cells to be used in "home talkie" outfits; and new types have been developed to meet it. But the more interesting new demand is for cells for television. Here the gasfilled cell, suitable for sound films, fails because its inevitable "time-lag" is fatal at the very high frequencies involved; vacuum cells have to be used, in which there is no amplification by gasfilling. Higher primary cathode emissions are required, and at the same time very large cells with great cathode areas.

New methods of manufacture are being devised to meet this demand. Sufficient advance has been made to bring within sight—if not yet within actual achievement—the production of vacuum cells so sensitive that gasfilled cells, with all their inherent disadvantages, will be replaced even for purposes where high sensitivity is one of the chief requisites.

GASFILLED RELAYS.

The GT1 gasfilled relay continues to find a widening field of successful applications. An argon filled version of the GT1, known as the GT1A, having as its chief feature the stability of its control characteristic, is now on the market.

Two new types, the GT5E (5 amperes peak emission), illustrated in fig. 7, and the GT25E (25 amperes peak emission) have been developed, and are now being placed on the market. These should be of considerable use in spot-welders, battery-chargers, inverters and other equipment.

TUNEON INDICATORS.

A small tubular type of neon gas discharge lamp is now being made for use in wireless sets. Such a tube, if used in a set with automatic volume control, shows when the set is accurately tuned to an incoming signal. The cathode is a rod extending along the axis of the tube, and there is a small anode at one end of this latter. In addition, a small "priming" electrode ensures that the main glow is kept alight when the receiver is tuned to weak stations. The main neon glow has the appearance of a column of light which climbs up and down the cathode as the current through the lamp increases and decreases. The indicator is connected in the anode circuit of one of the variable mu valves, so that the height of the column is a maximum when the receiver is exactly tuned to the incoming signal. Tuning can be judged more accurately in this way than by listening to the output from the loudspeaker.

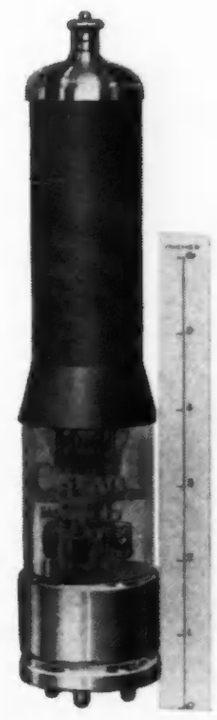


Fig. 7.—Gasfilled relay, type GT5E.

GENERATING PLANT.

The number of generators built during the last year is greater than for some years past, while the placing of contracts for machines of large capacity is of great significance as illustrating the headway which the industrial revival is making. Two turbo-alternators each of 62,500 kVA capacity are being built at Witton for the Hams Hall Power Station, Birmingham, while for overseas a 20,000 kW turbo set is under construction for Johannesburg Municipality, and two further machines of the same type, with capacities respectively of 15,000 kVA and 7,500 kVA for Palestine Electric Corporation. A view of the stator for one of the 62,500 kVA units is shown at fig. 8.

As in previous years a very considerable proportion of the smaller generators are either for gearing to pass-out turbines in connection with process steam supply in factories, or for coupling to reciprocating engines to meet overseas demands.

Turbo-alternators for outputs up to 1,500 kW at 3,000 r.p.m. are now manufactured in more compact form, a careful investigation of the design having resulted in a machine of small dimensions and light weight. This has been attained without in any way impairing efficiency and reliability. The frame of the machine is of fabricated construction thus conforming to standard G.E.C. practice for machines of this type.

There is a growing tendency in favour of building turbo-alternators capable of generating at transmission voltages, thus eliminating the need for step up transformers. Many difficult problems in connection with the insulation of the stator windings have thus had to be faced. As a result of long continued and careful investigation insulated

windings are now being produced which possess the requisite high dielectric strength, low dielectric loss and absence of corona discharges.

RECTIFIERS AND CONVERTING PLANT.

The use of the mercury arc rectifier in this country though not as yet very extensive is increasing steadily and several units of this type have been, or are being constructed both for home and overseas installation including four for the Borough of Poplar, four for the Borough of Stepney, four for one of the North Eastern Electric Supply Company's sub-stations, two for Sheffield Corporation and one for Copenhagen municipality.

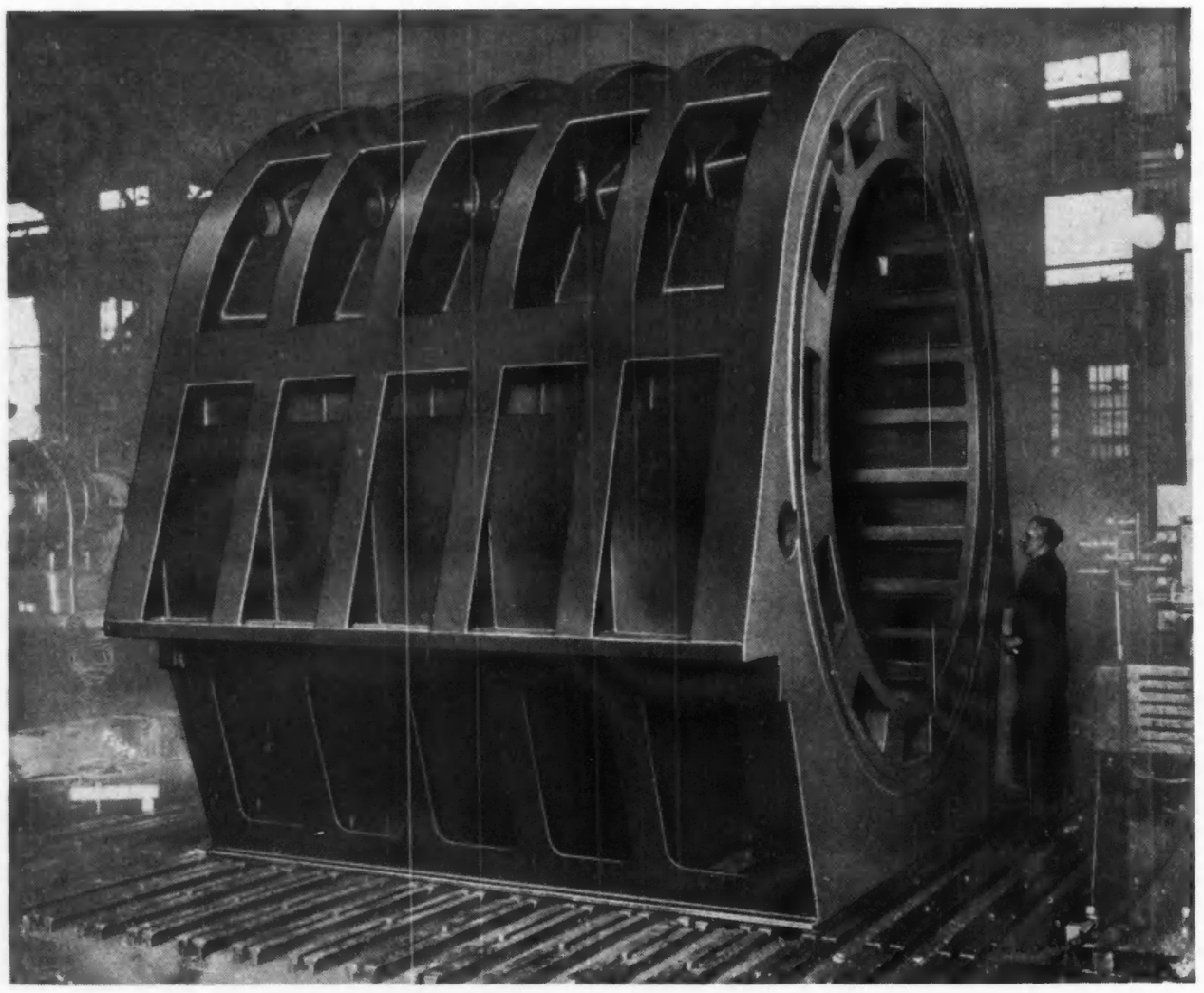


Fig. 8.—Stator for 62,500 kVA turbo-alternator for Hams Hall Power Station, 11,000 volts, 3 phase, 50 cycles, 1,500 r.p.m.

A 5,000 kW frequency changer was recently shipped to Nova Scotia for Dominion Coal Co., Ltd. Constructional views of this set are shown at figs. 10 and 11. It links together a 25 cycle and a 60 cycle system. The two systems are already linked together by an existing frequency changer so that special provision has had to be made for synchronising both ends of the new set to the respective systems.

Since the 25 cycle machine has 10 poles and the 60 cycle machine, 24 poles, the set can be synchronised to the one system in several angular positions where synchronisation with the other system is impossible. In order to ensure the possibility of synchronisation, change-over switches are provided for both machines for the purpose of slipping poles, and final adjustment is obtained by rotating the stator of one of the machines by means of special rocking gear.

INDUSTRIAL MOTOR APPLICATIONS.

The electrification of Ryhope Colliery, County Durham, forms one of the most comprehensive and interesting colliery schemes ever undertaken. In view of its importance it is described in a separate article in this issue.

The electrical equipment for a semi-continuous bar and strip mill at the Courtybella Works, Newport, of the Whitehead Iron & Steel Co. affords a prominent example of steelworks electrification. This installation was described in a recent issue of this Journal[3] and need not here be further referred to.

Of further comprehensive industrial electrification schemes undertaken, one of the most prominent is for the paper mills of Edward Lloyd Ltd., and includes the provision of seven induction motors, each developing 2,500 h.p. at 250 r.p.m. for process work. They are provided with phase advancers in the rotor circuit in order to improve the power factor of the system.

Each phase advancer is driven by a small induction motor at about 1,000 r.p.m. It consists of a stator similar to an induction motor, provided with two windings, and a rotor with a large commutator similar to a d.c. armature. The brushes on the commutator are connected to the sliprings of the main motor with a compensating winding on the stator of the phase advancer. This compensating winding ensures perfect commutation.

The second winding on the stator is a shunt winding connected across the main sliprings in series with a regulating rheostat which is used for adjusting the power factor. The addition of this shunt winding provides for power factor correction at low loads, which is not possible on the purely series type of phase advancer. This power factor correction at low loads is particularly desirable, since the motors are required to run almost light at certain periods. In these conditions the phase advancers are able to supply leading wattless current to the line, whereas with the series phase advancer a lagging wattless current would be drawn from the line.

The activity in the gold mining industry is mainly responsible for a number of electric winding motors which are being manufactured for export to South Africa. They are in the majority of cases direct current motors with Ward Leonard control. Four of them, each of 1,250 h.p., are for West Rand

(3) G.E.C. Journal, Vol. V., No. 3, p. 150.

Mines, one of 2,400 h.p. capacity is for the Roodeport Mines and another of 1,100 h.p. for Robinson Deep Mines. In addition, many large synchronous motors are under construction for driving tube mills, fans, compressors and other mining plant in South African mines.

The electrification of the Cyprus Copper Mines should be mentioned. The scope of this scheme is indicated by the fact that seventy motors are required; the two largest are for driving Hardinge ball mills. The generating plant consists of two 850 kVA oil engine driven alternators, while a truck cubicle switchboard and several transformers form part of the equipment.

An electrically driven air compressor with Ward Leonard control at New Hucknall Colliery (fig. 12) forms part of a conversion scheme presenting features of unusual interest. A full description of the scheme[4] has been published by R. W. Edwards, the chief engineer of the colliery.

The complete electrification of a hot strip rolling mill in Sheffield provides for the manufacture of four large rolling mill motors and several of smaller capacity; the machine for driving the roughing mill is of 1,500 h.p. output. Control of the motors is by means of remote operated contactor equipment. Other motors for steelworks electrification schemes include one for rolling mill drive in Australia.

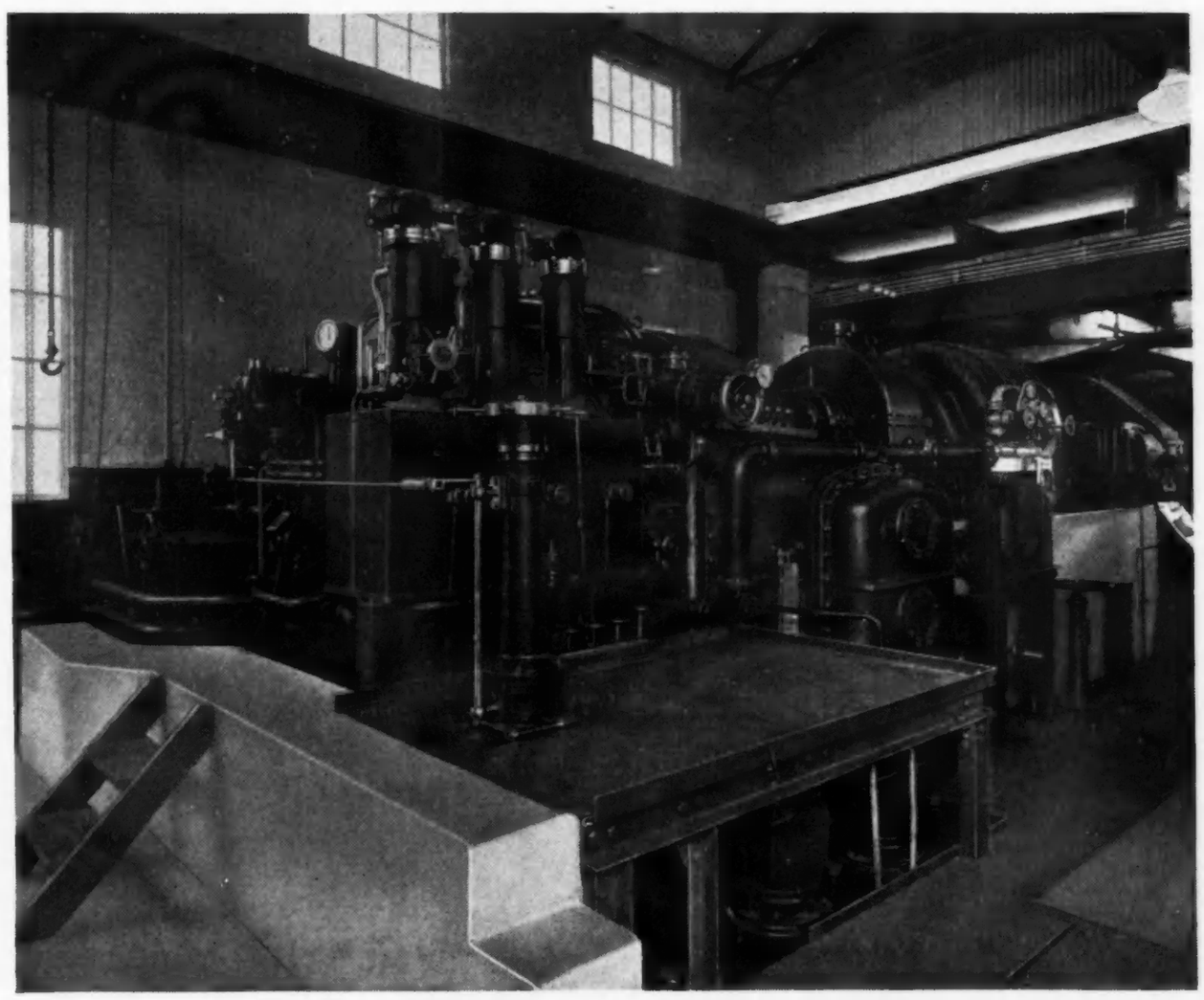


Fig. 9.—2,000 kVA geared turbo-alternator, 440 volts, 3 phase, 50 cycles, turbine speed 6,000 r.p.m.; alternator speed 1,500 r.p.m., installed at Donside Paper Mills.

Several textile mills are being electrified, the two most prominent examples being situated respectively in China and Egypt. The equipment for the mills in China consists of two geared turbo-alternators, main switchgear and over 100 squirrel cage motors, of which a number are of the cowl-cooled pattern shown in fig. 15. The Egyptian mills installation includes a geared turbo-alternator, a standby oil engine driven alternator, five hundred $\frac{3}{4}$ h.p. loom motors, pump motors and motor control gear. It is not possible to refer individually to further industrial schemes which have been undertaken, but industries in which electrification is making marked progress include paper making, quarries, food preparation, and various sections of the chemical industries.

TOTALLY ENCLOSED AND FLAMEPROOF MOTORS.

A new method for the external cooling of a totally enclosed motor has been applied to a range of alternating current motors, fig. 15, to which the name "cowl-cooled" has been given. An external fan under a protecting cover delivers air axially over the outer case of the motor, and as this case is fitted with axial ribs very effective cooling is provided, with the result that increased rating is obtainable from a machine of given frame size.

Interesting features have been incorporated in the design of a totally enclosed direct current motor, fig. 16. A cast aluminium diaphragm is fitted to the driving end of the motor, being enclosed by an end bracket of the standard type employed for a protected machine. The diaphragm casting embodies a number of projections which form radial ducts for the internal cooling air and offer a large radiating surface to the external air. On the inside of the casting a baffle is formed which ensures that the air inside the motor thoroughly "scrubs" the walls of the duct, thereby enabling the maximum amount of heat to be transferred through the aluminium casting to the external air.

Improvements have been effected in the design of flameproof colliery motors including the barrel type of machine and the motor embodied in coal cutters, fig. 17.

BUILT-IN MACHINE TOOL MOTORS.

Stator and rotor units have been developed for building into machine tools. These are available in several forms. One which should be noted is a three phase four speed drill motor giving a horsepower of .95 at any one of four speeds, *e.g.*, 3,000, 1,500, 1,000 and 500 r.p.m., or alternatively 1,500, 1,000, 750 and 500 r.p.m., depending upon require-

(4) Colliery Guardian, Sept. 28th, 1934.

ments. A second example is represented by a rotor and stator designed for giving ½ h.p. at 1,440 r.p.m., while a third takes the form of a repulsion induction motor capable of ⅓ h.p. at 1,440 r.p.m.

ELECTRIC FANS.

A new design of ship fan has been introduced for use in cabins which is suitable for bulkhead mounting. It is of the oscillating pattern being provided with an adjustment allowing the centre of the arc of oscillation to be moved into the position most convenient for the passenger. The angle of the fan relative to the horizontal may also be adjusted through a very wide range, allowing it to deliver air in any direction from the horizontal to the vertical position.

This fan can be mounted in a shoe which is screwed to the cabin wall or ceiling and the fan can be removed from the show without disturbing the paintwork. This makes it possible to mount the fan in a variety of positions provided that the necessary shoes are mounted in the cabin.

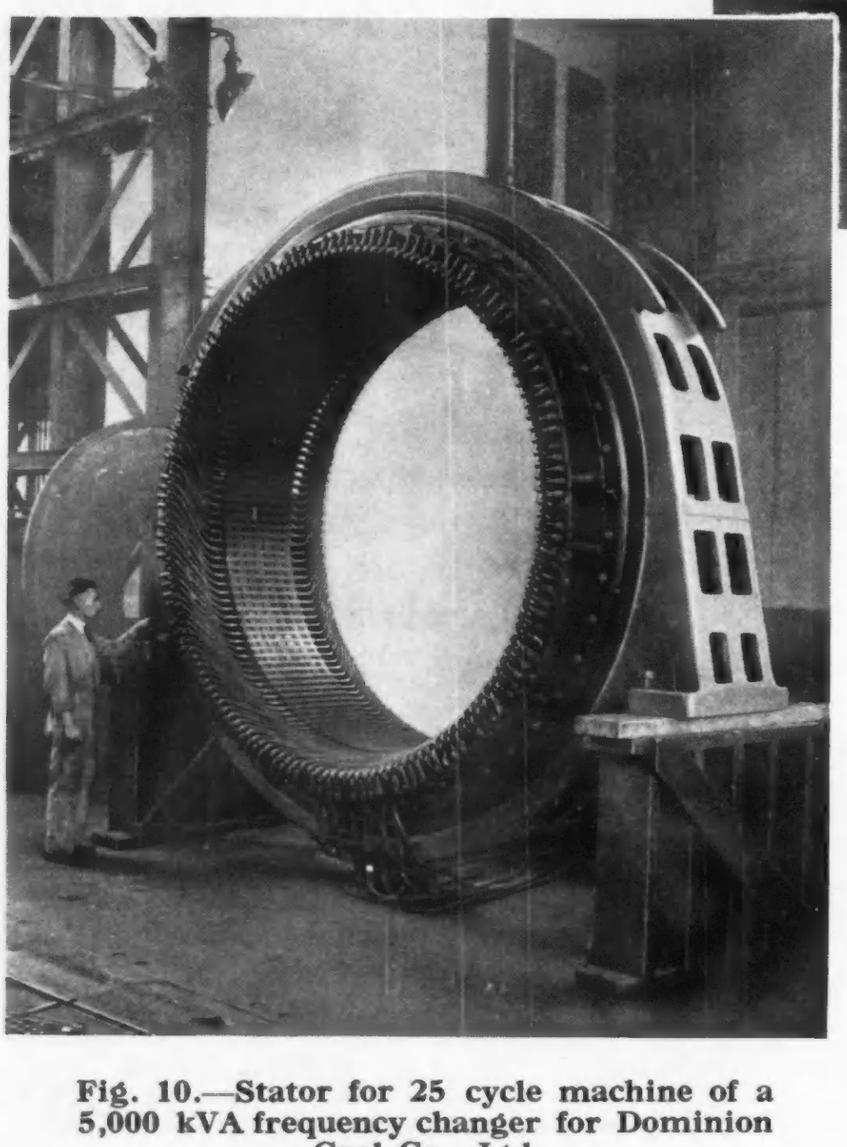


Fig. 10.—Stator for 25 cycle machine of a 5,000 kVA frequency changer for Dominion Coal Co., Ltd.

A new form of patented regulator[5] has been standardised for induction type desk fans. This regulator has the low watt consumption of the choker type of regulator, but at the same time embodies a feature which enables the regulator to be adjusted to suit the particular characteristic of the fan with which it is used.

A considerable amount of work has been done in the direction of eliminating radio interference and fan motors can now be supplied for use on board ship embodying an elimination device built into the fan motor itself.

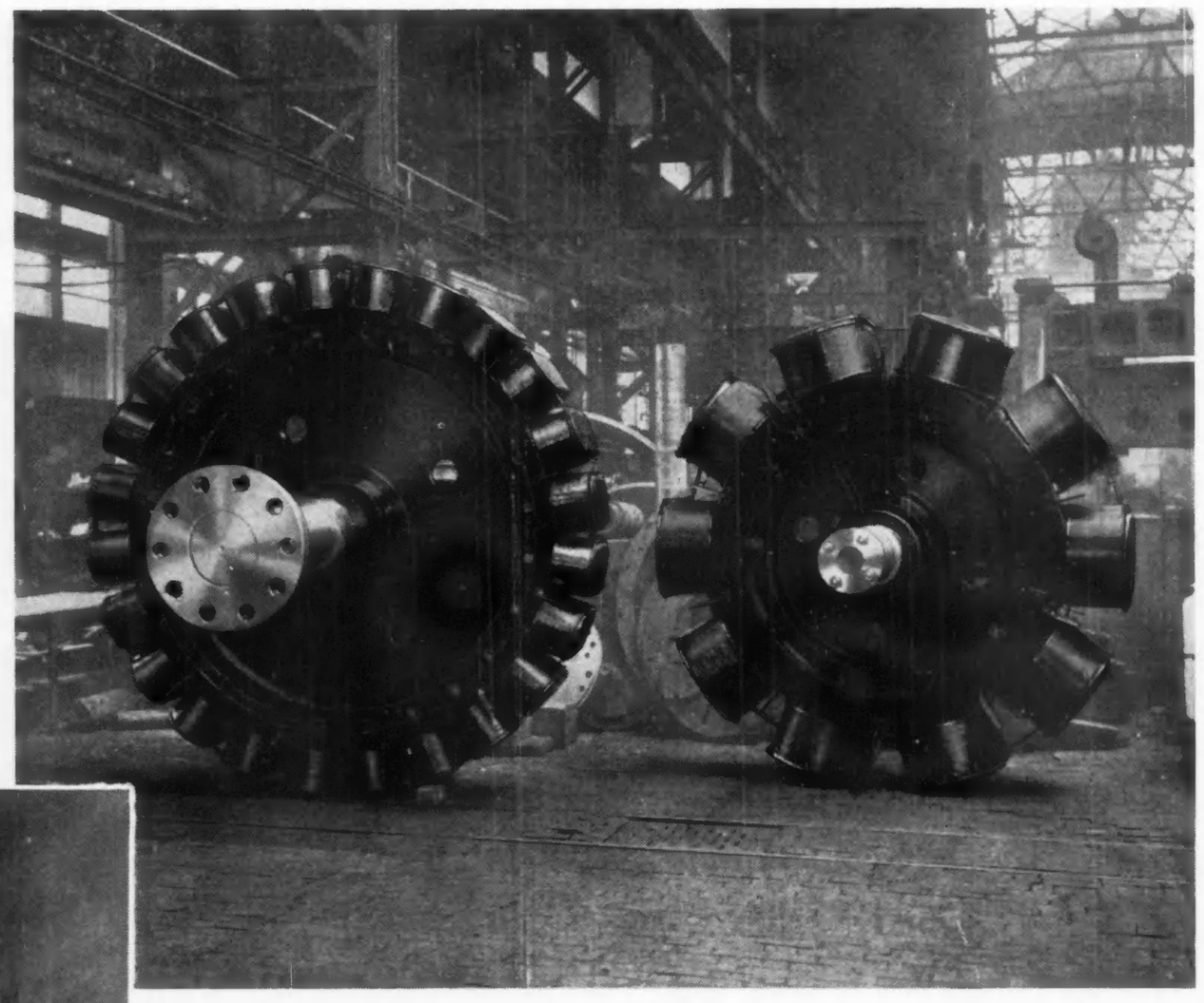


Fig. 11.—View of 25 and 60 cycle magnet wheels for same frequency changer.

METALCLAD SWITCHGEAR.

A special system of fixed and moving contacts is required in order to provide split conductor protection on vertical isolation, duplicate busbar metalclad switchgear in which changeover from one busbar to the other is effected by transference of the breaker from one position to another while in the disconnected or isolated position. A system, covered by patents[6] has been evolved which is shown at fig. 19.

In metalclad switchgear embodying transfer breakers the busbar plugging spouts are disposed one behind and one in front of the cable plugging spout. There are thus only three plugging spouts "A," "B" and "C" per phase, the centre spout, "B," being used for both breaker positions so that either terminal of the breaker may be connected with the cable.

When split conductor protection is employed, it is necessary to carry the splitting or separation of the two parallel conductors, or "splits" right up

(5) Patent applied for.

(6) Patent No. 406775.

to the break contact in the circuit breaker, so that when the breaker opens, the splits shall be electrically isolated one from the other. Also, in order to secure a high degree of sensitivity of operation, it is necessary when closing the circuit breaker to energise both splits at precisely the same instant.

In a circuit breaker in which the same terminal is always connected to the cable, *e.g.*, on a single busbar system, this may be accomplished by providing on that terminal of the circuit breaker longer breaking contacts than those on the terminal which is connected to the busbar. When the circuit breaker is being closed, contact is thus established earlier on the cable side than on the busbar side, so that the splits are paralleled before being energised.

In switchgear of the transfer breaker type, the construction of either terminal of the breaker must provide for connection to the cable, so that the splits are paralleled before energisation.

To obtain the desired conditions, the splitting of the conductors is carried down each terminal to the point of break, and in addition to the normal break contacts there are provided on each terminal two extra contacts "D," "H," one on each split. On each end of the moving contact, but insulated from it is mounted a bridging contact "E" to engage with the two contacts mentioned above.

The bridging contacts are made longer than the normal circuit contacts, so that each pair of splits is definitely paralleled before the circuit is completed between the terminals. The presence of the extra contacts and the bridging contact upon that terminal which is connected to the busbar does not in any way affect the point at issue, as the splits on that terminal are paralleled at the busbar plugging socket, whenever the breaker is in service position.

CUBICLE SWITCHGEAR.

The majority of cubicle switchgear manufactured is of standard design, but it is of interest to record the building of an 11,000 volt truck cubicle switchboard (fig. 20) equipped with oil circuit breakers of 500,000 kVA maximum rupturing capacity, which is one of the largest of its type ever built.

In connection with the extension to Hams Hall Power Station, Birmingham, a 10-panel remote controlled stonework cubicle switchboard, with oil circuit breakers of 750,000 kVA rupturing capacity is to be installed, also a 15-panel ampere metalclad switchboard for controlling transformers and feeders.

A cubicle for housing mercury arc rectifier control apparatus, fig. 21, has been standardised. Its equipment includes gear for controlling the cooling water pump and fan, vacuum pump

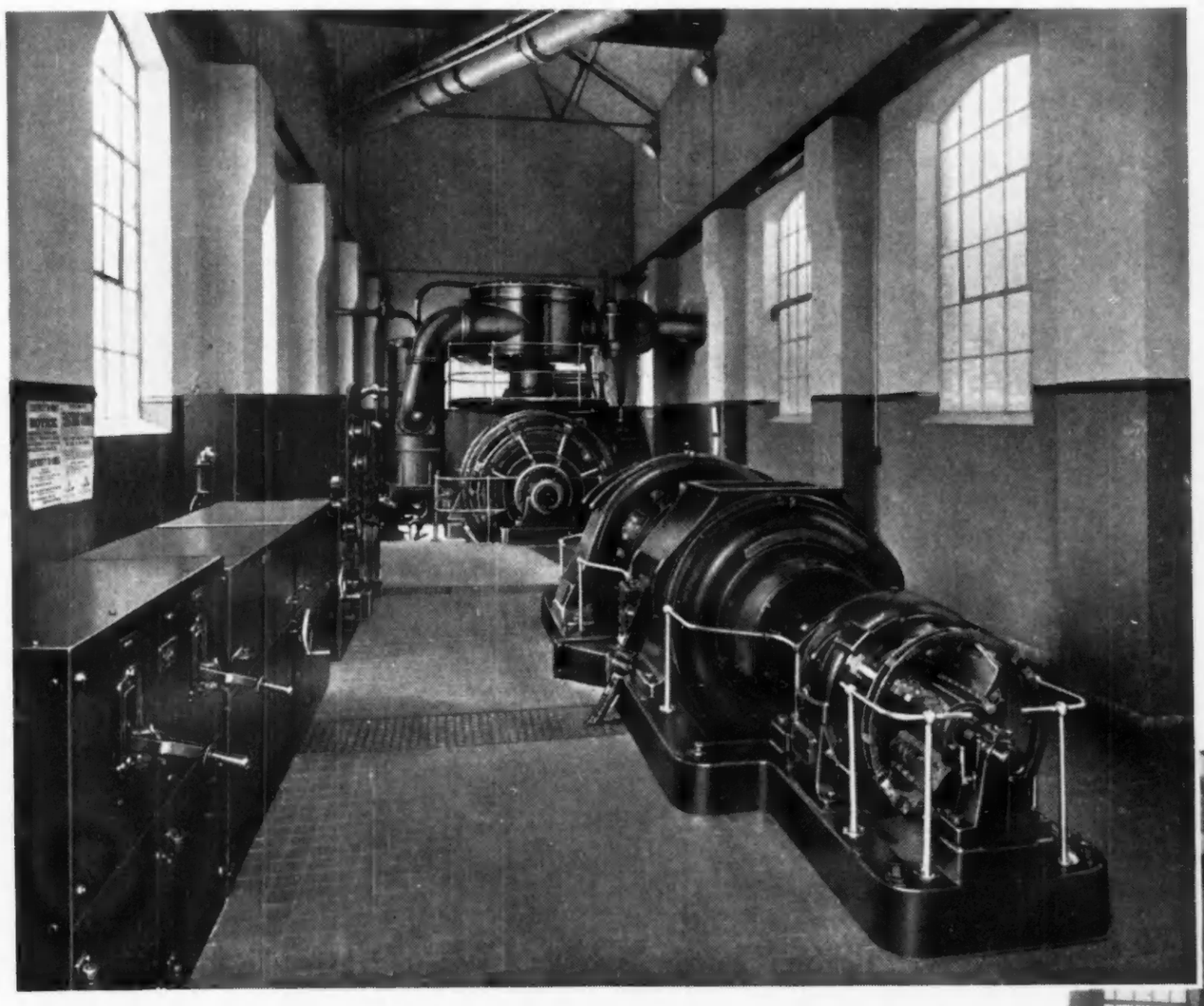


Fig. 12.—General view of air compressor equipment at New Hucknall Colliery, showing in the foreground a 725 kW 1,000 r.p.m. Ward-Leonard motor generator set, and in the background a 240/920 h.p. D.C. motor driving the compressor.

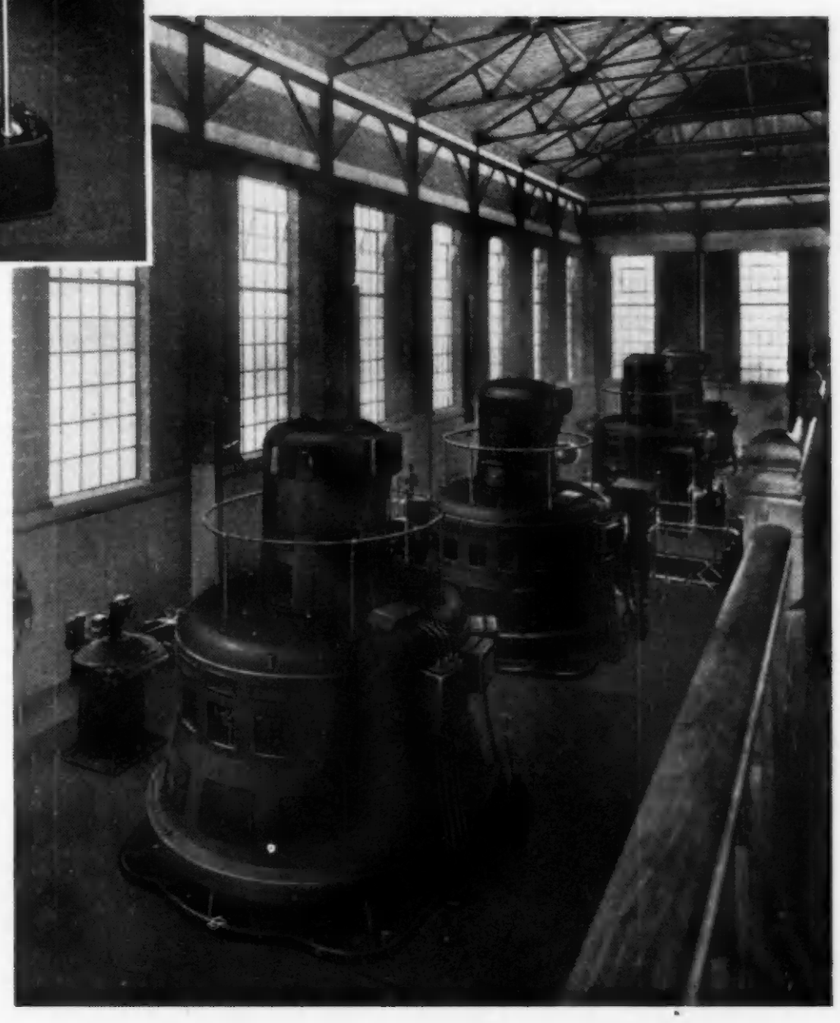


Fig. 13.—Four 1,200 h.p. 6,600 volt synchronous induction motors driving pumping equipment at King George V. Graving Dock, Southampton.

equipment and ignition apparatus. The protection afforded to relatively small contactors and relays is a valuable feature.

AUTOMATIC REGULATION AND LOAD SHARING.

In the case of a multi-unit mercury arc rectifier

Fig. 14.—Two 135 h.p. squirrel cage motors, 3,000/3,300 volts, 3 phase, 50 cycles, 3,000 r.p.m., direct coupled to Sulzer Pumps at Cefn Coed Colliery.

sub-station recently put into service, it was necessary to arrange the control of each rectifier as a separate unit, and yet when any two equipments were supplying a common feed they were required to give a compound characteristic of voltage and also share the load. This is effected by relays of the voltage regulating type, one of which controls the

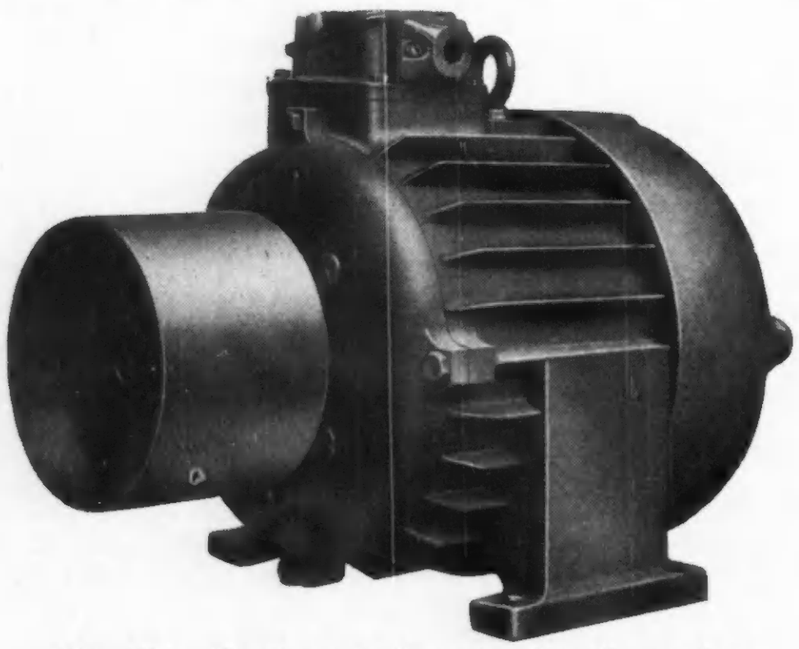


Fig. 15.—Cowl-cooled squirrel cage motor.

voltage of each rectifier by regulating the taps on the main transformer. Each relay has shunt and series windings to give a rising characteristic of voltage, also an additional winding which carries a proportion of its load current and is arranged so that if the particular rectifier is supplying less than its share of load its rising characteristic is increased and conversely if the particular rectifier is supplying more than its share of load its rising characteristic is reduced. Thus a lighter loaded machine tends to increase its voltage and a heavier loaded machine to decrease its voltage, the arrangement producing stability when the load is equally shared.

Fig. 16.—Diaphragm-cooled D.C. motor, with end bracket removed to show diaphragm.

AUTOMOBILE TESTING SETS.

The success which has attended the installation of automatic equipments for testing automobile engines in the works of several leading motor car manufacturers has led to an addition to the range of a high-speed testing set for sports engines.

For testing back axles, apparatus has been

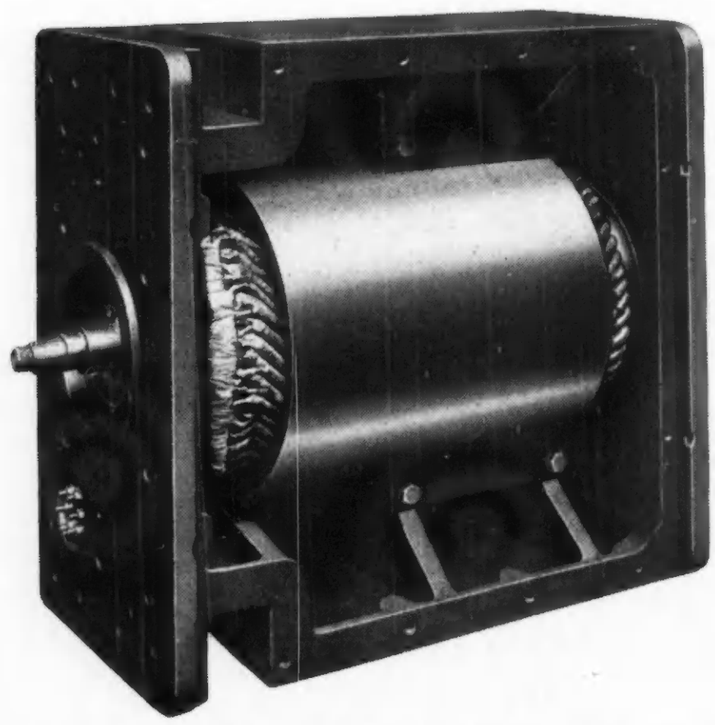


Fig. 17.—35 h.p. 400 volt coal cutter motor.

designed capable of testing at full load over the whole speed range both for forward-running and over-running. Speeds and gear ratios can be adjusted by simple handwheel operations.

ROLLING MILL CONTROL DEVICES.

Reference was made earlier in this article to the electrification of a strip mill in Sheffield. Provision has to be made for bringing the main mill to rest in approximately ten seconds. The braking is effected by reversed main connections, while special relays which compare rotor and stator frequencies disconnect the motor as it comes to rest, thus ensuring that no reverse rotation takes place.

The application of electricity to Bliss rolling mills has been extended by the addition of a constant tension coiling apparatus. This maintains a constant predetermined pull on the strip as it emerges from the mill, independent alike of the speed and the diameter of the coil.

DUPLEX KLYDONOGRAPH.

A number of Supply Authorities are adopting the plan of fitting means for recording the occurrence and magnitude of lightning surges which are set up on their systems. The simplest and most reliable method of doing this is by means of the klydonograph, an instrument based on the "figures" discovered by Lichtenberg a century and a half ago. They are produced photographically by impressing the surge voltage which has to be measured between a small electrode resting on the film and a metallic disc at the back of the glass of the sensitive plate. Upon development of the latter, figures resembling fig. 25, are obtained, the exact shape depending on the polarity of the surge; and the magnitude of the voltage can be found by measuring the longest ray in the positive figure. When this method has been employed, it has hitherto been usual to have two of these instruments at each point, namely, one to record the positive surges and the other to record the negative, but a very simple instrument, fig. 23 has been designed whereby both surges can be recorded by the one piece of apparatus. This has the same linear dimensions as the single acting instrument, but possesses two sets of electrodes, the photographic plates being inserted back to back. The working part of the apparatus is contained in an outdoor porcelain housing.

LIGHTNING ARRESTERS AND H.V. LIQUID FUSES.

Surge valve type arresters, of which a typical example is shown in fig. 27, have been developed for a wide range of voltages from 250 to 11,000 volts. The 600-volt type previously used on A.C. circuits has been shown to be suitable for direct current of this voltage and for alternating current up to 1,000 volts. A further pattern has therefore been produced suitable for 250 volts D.C. and 600 volts A.C. This type of arrester has the characteristic that it is able to pass a relief current which increases enormously with rise of voltage, and therefore has a true valve action exactly analogous to that of the steam safety valve.

Fig. 18.—6,600 volt metalclad switchboard, 500,000 kVA breaking capacity, installed in the power station of Newport Corporation.

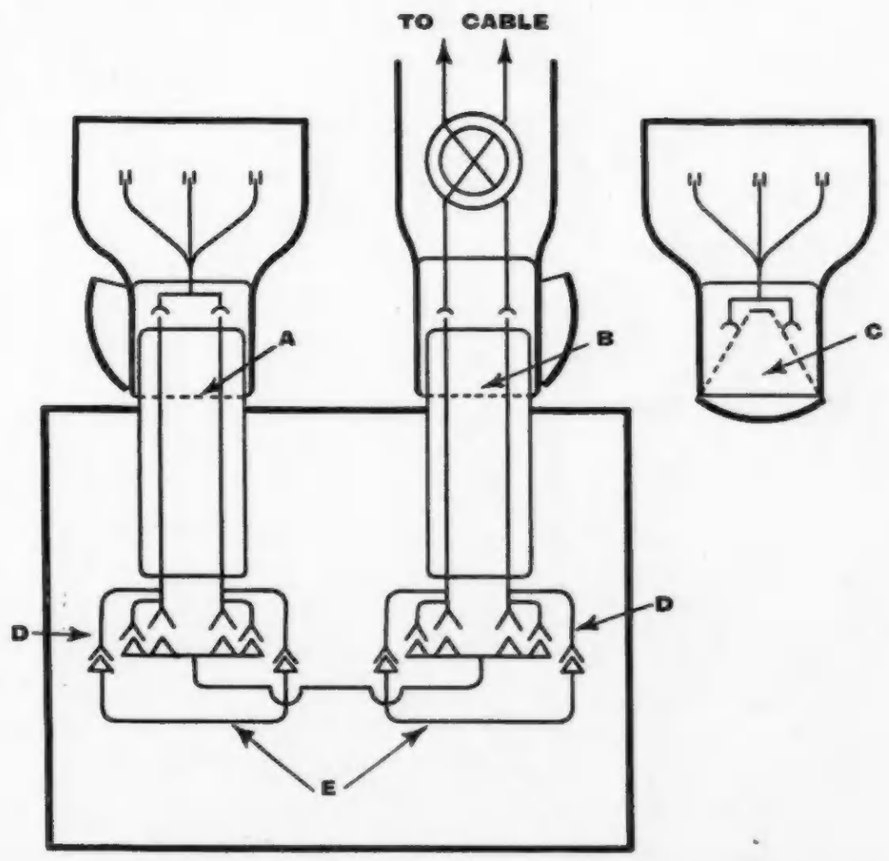


Fig. 19.—Diagram illustrating special system of fixed and moving contacts to provide split conductor protection on vertical isolation, duplicate busbar switchgear.

Records of the performance of these arresters are given in figs. 24, 25 and 26. Fig. 24 shows an ordinary oscillograph illustrating the cancellation of

the follow current after a discharge, the current being suppressed in every instance within half a cycle. The two klydonograms, figs. 25 and 26, were taken of an 850 kV surge applied to a 6.6 kV line from the lightning generator installed in the high tension laboratory at Witton before and after the lightning arrester, shown in fig. 27, had been connected. It will be seen that the voltage of the surge has been reduced to a peak value not greater than 16 kV or about one-fiftieth of the original value.

A range of cone type vertical fuse-isolator mountings has been introduced for use with high voltage "Quenchol" type liquid fuses. They may be used either for indoor or outdoor purposes and are suitable for fusing currents from 1 to 25 amperes at voltages up to 22,000.

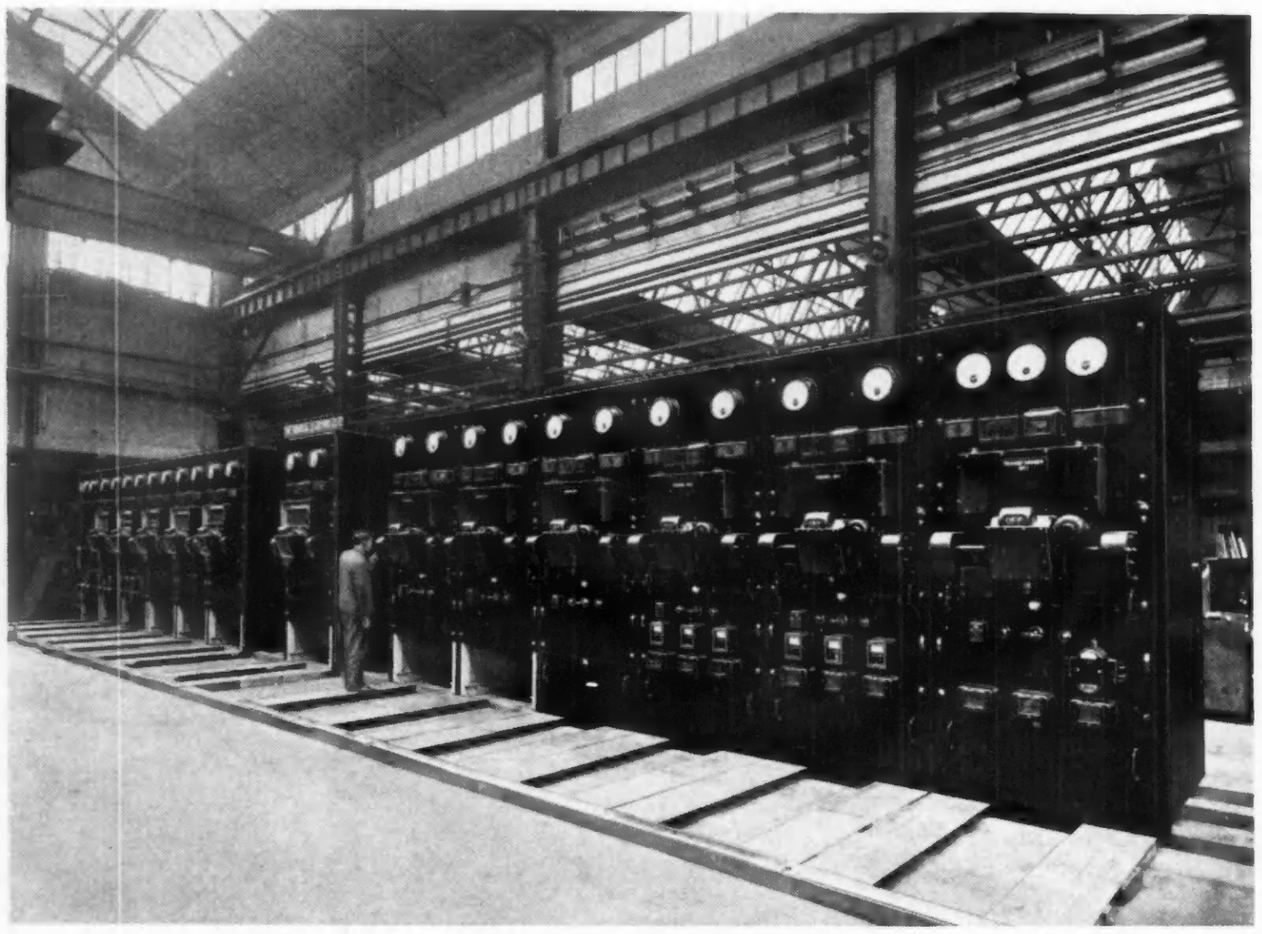


Fig. 20.—6,600 volt truck cubicle switchboard, 500,000 kVA breaking capacity, for the paper mills of Edward Lloyd Ltd. View taken during erection in the H.T. switchgear works.

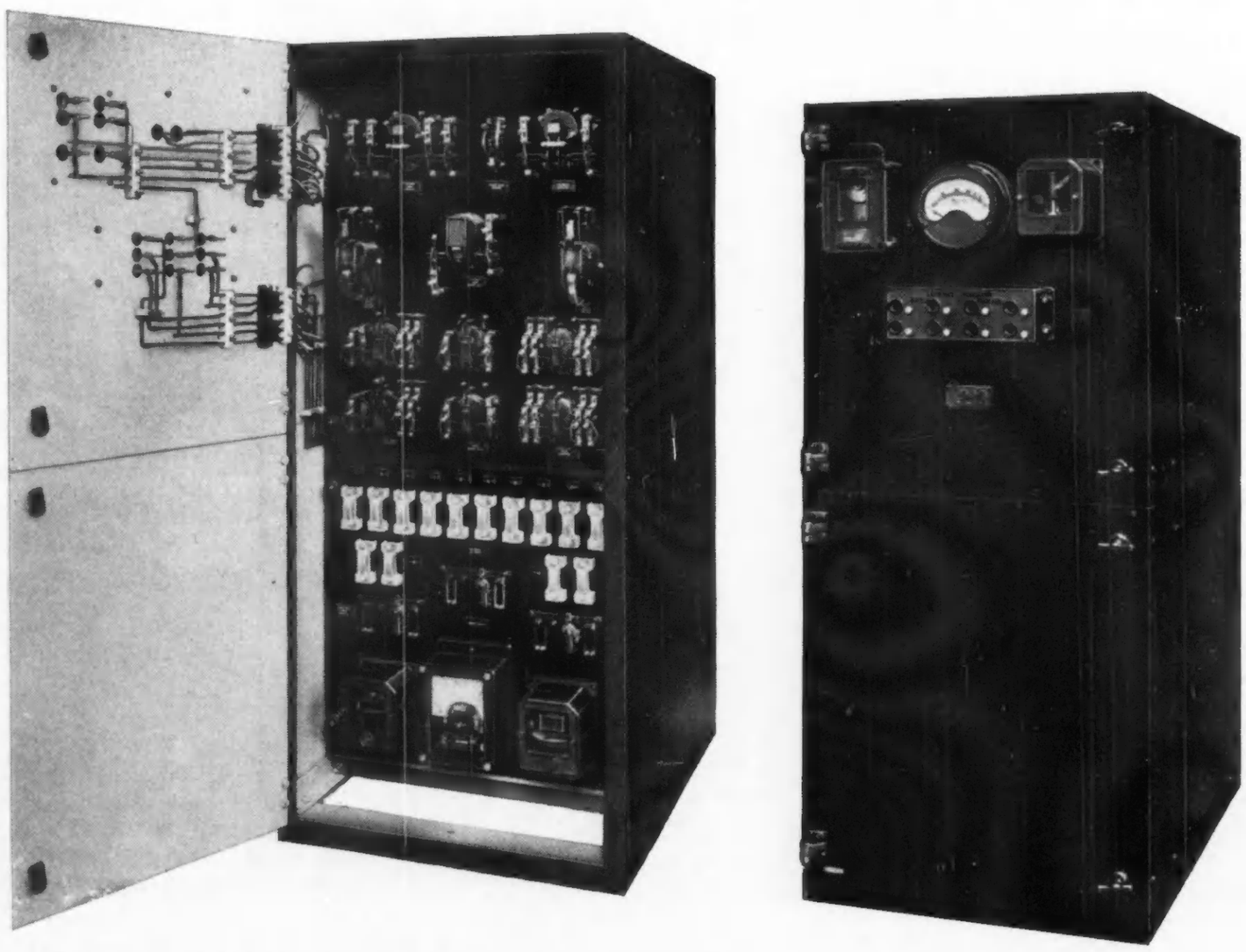


Fig. 21.—Two views of auxiliary control cubicle for steel tank mercury arc rectifiers.

MULTI-CIRCUIT OSCILLOGRAPHS.

Testing work involving the use of oscillographs has of late increased very considerably. Until recently this work was carried out by two-element oscillographs, but the testing facilities have now been greatly improved by the design and manufacture in the Witton Development Department of much larger instruments. The first constructed was a six element instrument in which all the six mirrors were supplied from the one illuminant and optical system. These elements record upon

a photographic film 6 inches in width, usually in the form of a paper strip. Special drums were designed for enabling quick loading and unloading to be carried out, in daylight. The whole apparatus has been mounted on a "dinner waggon" and has proved most valuable for this type of test.

Fig. 22.—General view of engine testing bay at the works of Austin Motor Co., Ltd., showing 24 testing sets, each comprising motor and control gear.

A twelve-element oscillograph has also been completed, recording upon a paper or celluloid strip 12 inches wide by 22 inches in length. In this instance very definite illumination for each strip was secured by the use of four separate light sources

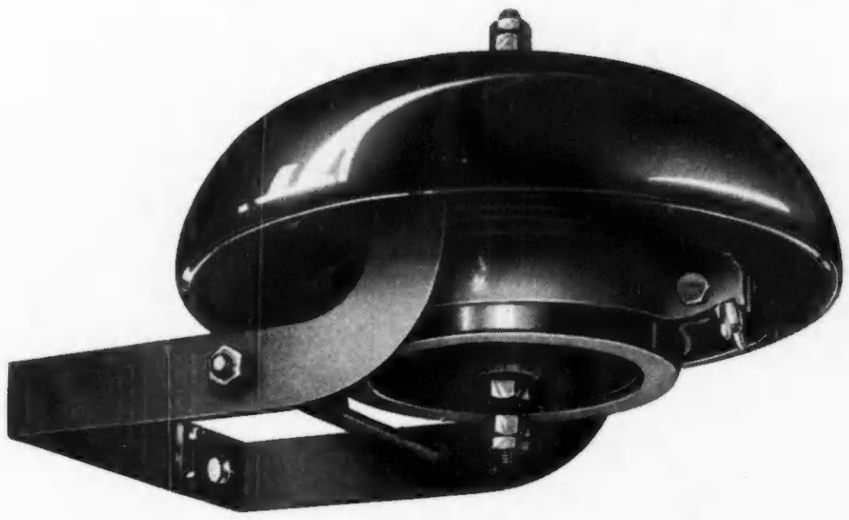


Fig. 23.—Duplex klydonograph.

and condensers, each one serving for three different strips. The apparatus has been mounted complete with all the necessary regulating resistances and calibrating arrangements for each element, and is undoubtedly a very convenient and easily operated oscillograph. It is fitted with an automatic shutter whereby the record is caused to start at exactly the right point in the short circuit which is being recorded.

Views of the twelve-element and the six-element oscillograph are given at figs. 28 and 29 respectively.

UNBALANCED PHASE PROTECTIVE SCHEME.

Protection to electric circuits is sometimes afforded in accordance with the negative phase sequence principle, which involves that, upon the occurrence of an earth fault, negative phase sequence current passes into the feeder from the fault. The usual method of detecting this current is by means of

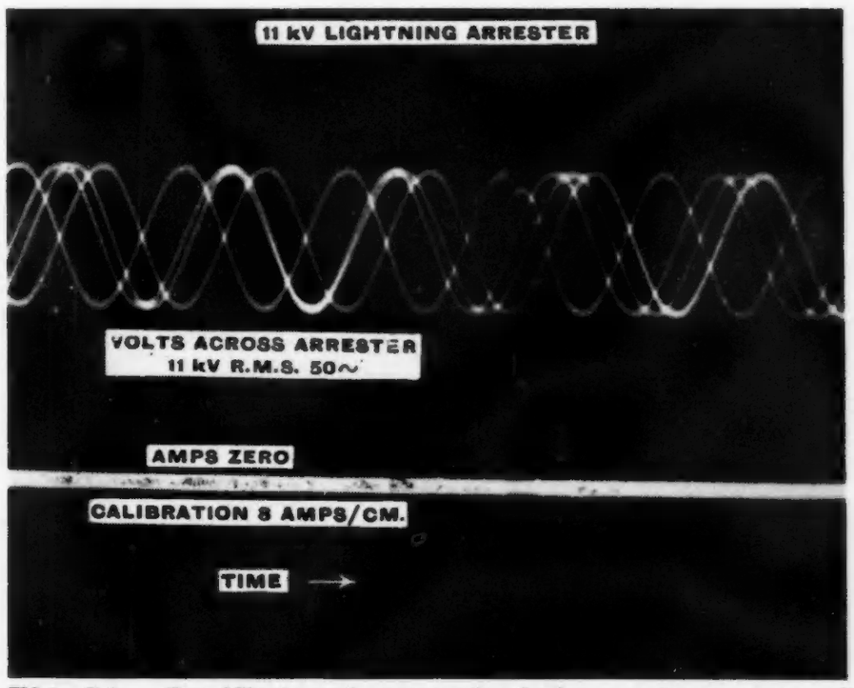
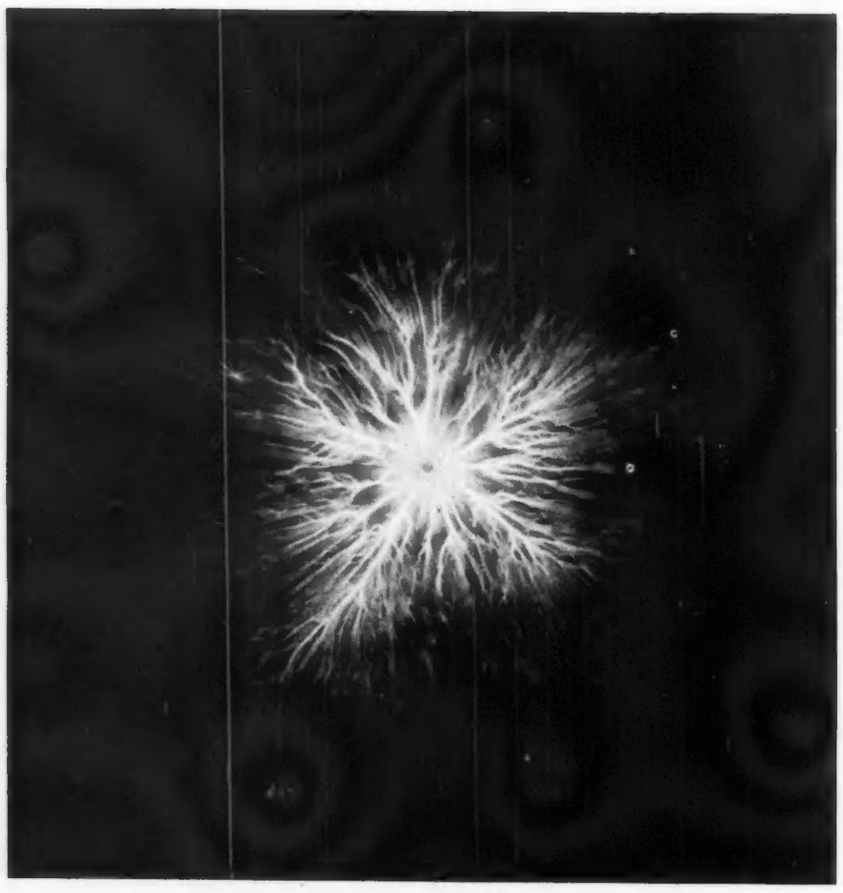


Fig. 24.—Oscillograph record of the performance of the lightning arrester shown in fig. 27.

phase filters, which will isolate the desired component of the unbalanced alternating current. This method, however, requires very careful balancing, more so than is usually practicable without introducing instability. The difficulty has been overcome by the design of a scheme with a biassed characteris-

tic which detects the unbalanced state of the current consequent upon the existence of the negative phase sequence component, without requiring to isolate the latter.

A number of feeders have been equipped with this type of protection in South West England and in Yorkshire. A high degree of sensitivity was afforded under adverse conditions on certain of these feeders by the use of a very fine spring control of the moving contact, together with a direct current kicking coil which ensures the return of the moving system to the "off" position following the removal of the fault.



Figs. 25 and 26.—Klydonogram records of 850 kV surge applied before and after inserting lightning arrester shown in fig. 27.

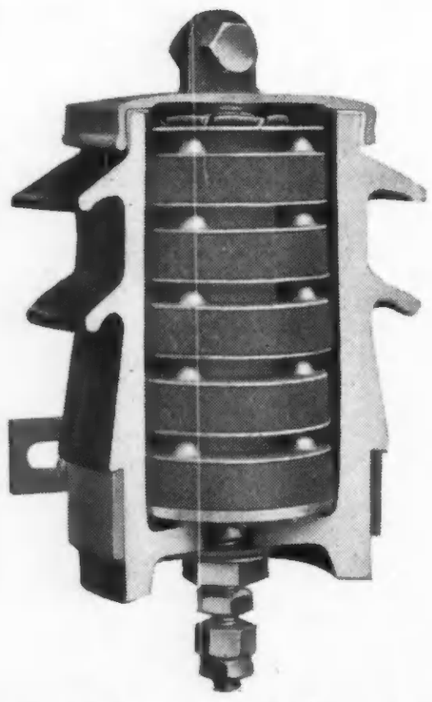


Fig. 27.—Sectional view of surge valve type lightning arrester.

PARALLEL FEEDER RELAY.

The biassed wattmeter type of relay employed for parallel feeder protection has been improved by the addition of a calibrating dial which enables the bias setting to be adjusted at any desired value, as marked upon the dial. This is a distinct advantage as although the spring setting of the relay, controlling the operation at light loads, could be adjusted by means of a dial, the bias has hitherto been adjusted in the test room, and if modifications were subsequently required the exact value to which the bias had been altered could not be determined without a further test.

VOLTAGE OR CURRENT REGULATING RELAYS.

A modification of the standard voltage or current regulating relay has been designed for heavy duty and high sensitivity. Relatively heavy contacts are fitted to the balanced beam system and these contacts are arranged to be held open by two latches operated from the beam.

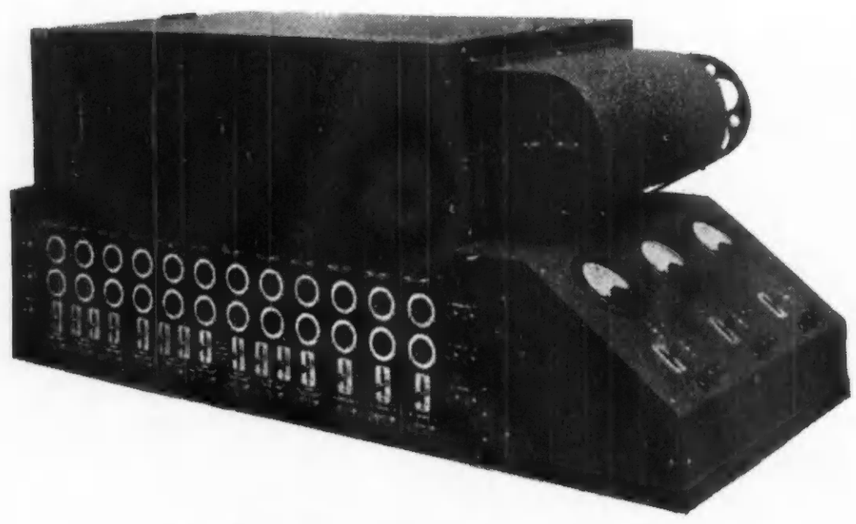


Fig. 28.—12-element oscillograph.

A small servo motor operating through reduction gearing on to a cam periodically takes the weight off these latches thus allowing the beam to move with a very small variation from the conditions of balance. As the cam advances, the contacts are released again and either re-engage with the latches

or if a correction is required the appropriate latch is tripped and the contacts close. Later, the further revolution of the cam breaks the contacts and allows the beam to re-engage the latch if sufficient correction has been made. If the correction carried out has been insufficient to restore normal conditions a further interval of correction is allowed during the next revolution of the cam. The cam is made in two halves which can be moved relative to each other to increase or decrease the contacting period; also by varying the speed of the servo motor the number of contacting periods per minute can be altered to suit various operating conditions.

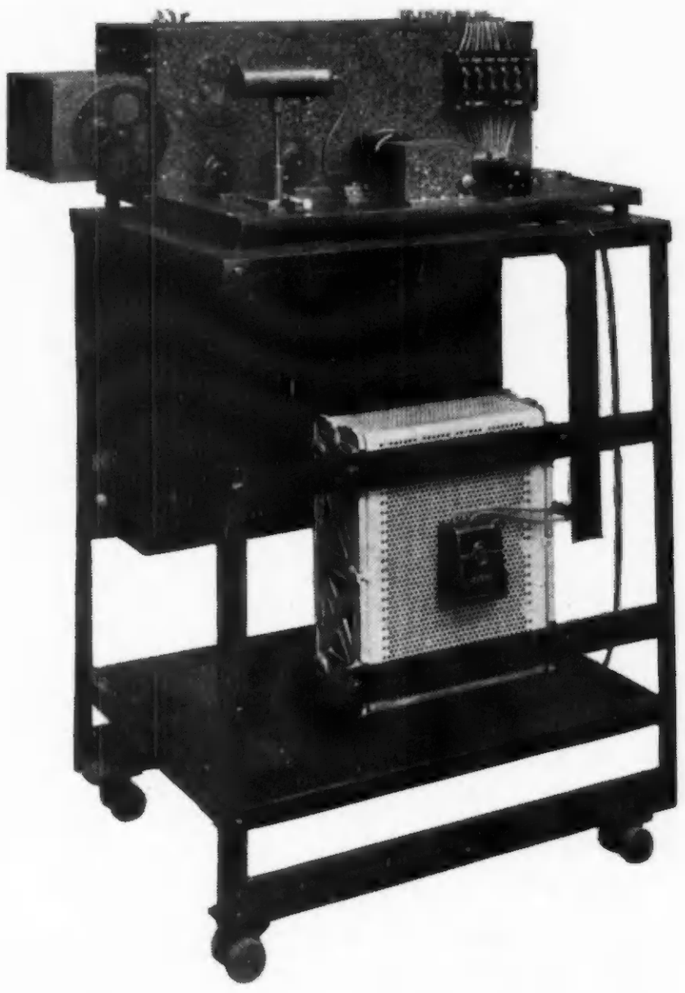


Fig. 29.—6-element portable oscillograph.

TIME SEQUENCE SWITCH.

Use has been made in the past of the clock-operated switch for controlling the running-in of petrol engines; but a more extended use has been made of the principle in a new design of time sequence switch in connection with the automatic operation of insulation presses. The usual practice is for a girl to be in charge of each press, and to operate the control handles at the desired intervals. A number of these presses have now been fitted with an automatic contactor control box, the functioning of which is governed by the opening and closing of contacts in a compact time sequence switch. The principle of this device is that the movement of the starting handle winds up the clock spring sufficiently to enable the moving contact to go through its cycle of operations in the desired time. A continuous adjustment for the time period is fitted, and it has been found that by virtue of the exact timing that can now be accomplished as compared with human operation, the time for the process can be very greatly reduced, it being possible to save

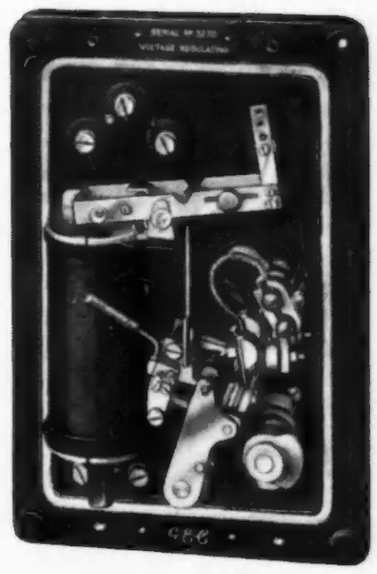


Fig. 30.—Voltage regulating relay.

nearly 50 per cent of the time originally taken in a number of instances. In addition to this saving, it is now possible for the one operator to control a number of separate machines.

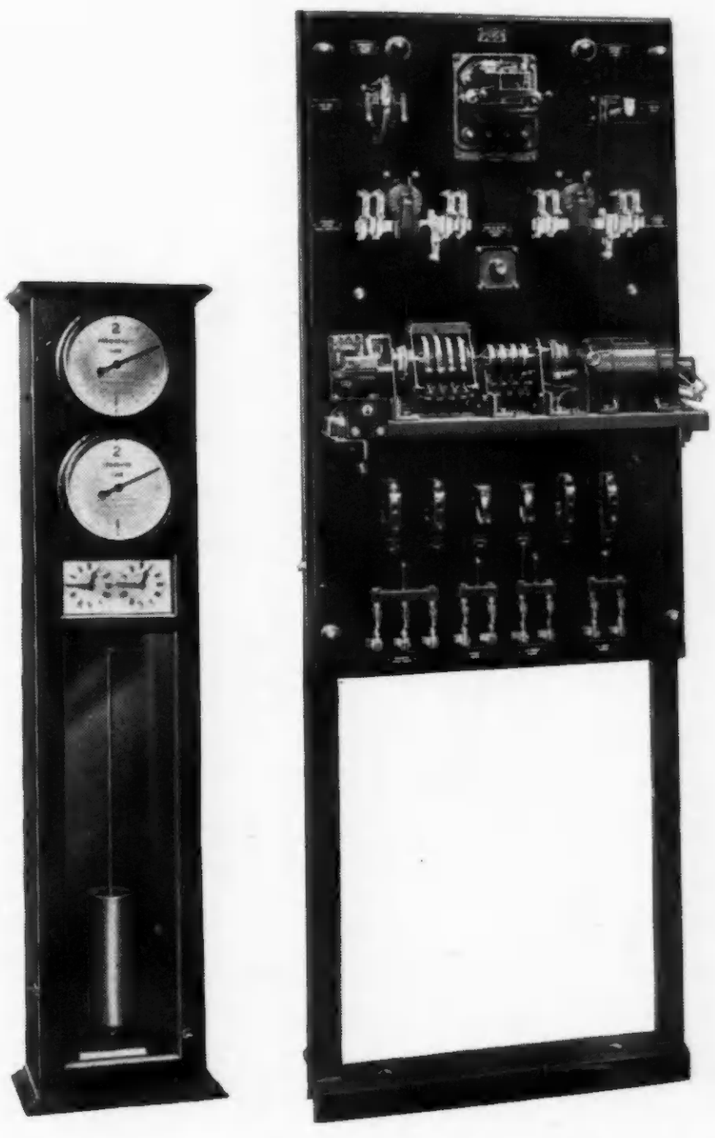


Fig. 31.—Master clock and control panel for automatic frequency control equipment.

DIRECT CURRENT REMOTE INDICATOR.

Remote indication has hitherto been chiefly required in connection with alternating current circuits. For certain purposes, however, including

ships and some power stations, a remote indicator is required to be operated by direct current, and a successful model has been devised possessing the advantages associated with the alternating current models in that the reading is determined by the proportionality between the currents in two circuits and is therefore independent of the value of voltage responsible for producing these currents.

The new indicator is in service in a large power station for indicating the position of tap changing gear. Variants have been developed for indicating the position of the helm of a vessel, whether electrically propelled or otherwise, and as an engine room telegraph.

HIGH FREQUENCY FURNACE CONTACTOR.

Contactors have been designed for operation at higher frequencies than those usually standardised. This has been necessary, for instance, in lighthouse practice, and for certain radio purposes where frequencies up to 500 cycles per second have been catered for by means of comparatively small units. The development of the electric furnace, however, called for contactors handling heavy currents at frequencies of 1,000 cycles, and a large high frequency contactor has therefore been developed and put into production for this special purpose.

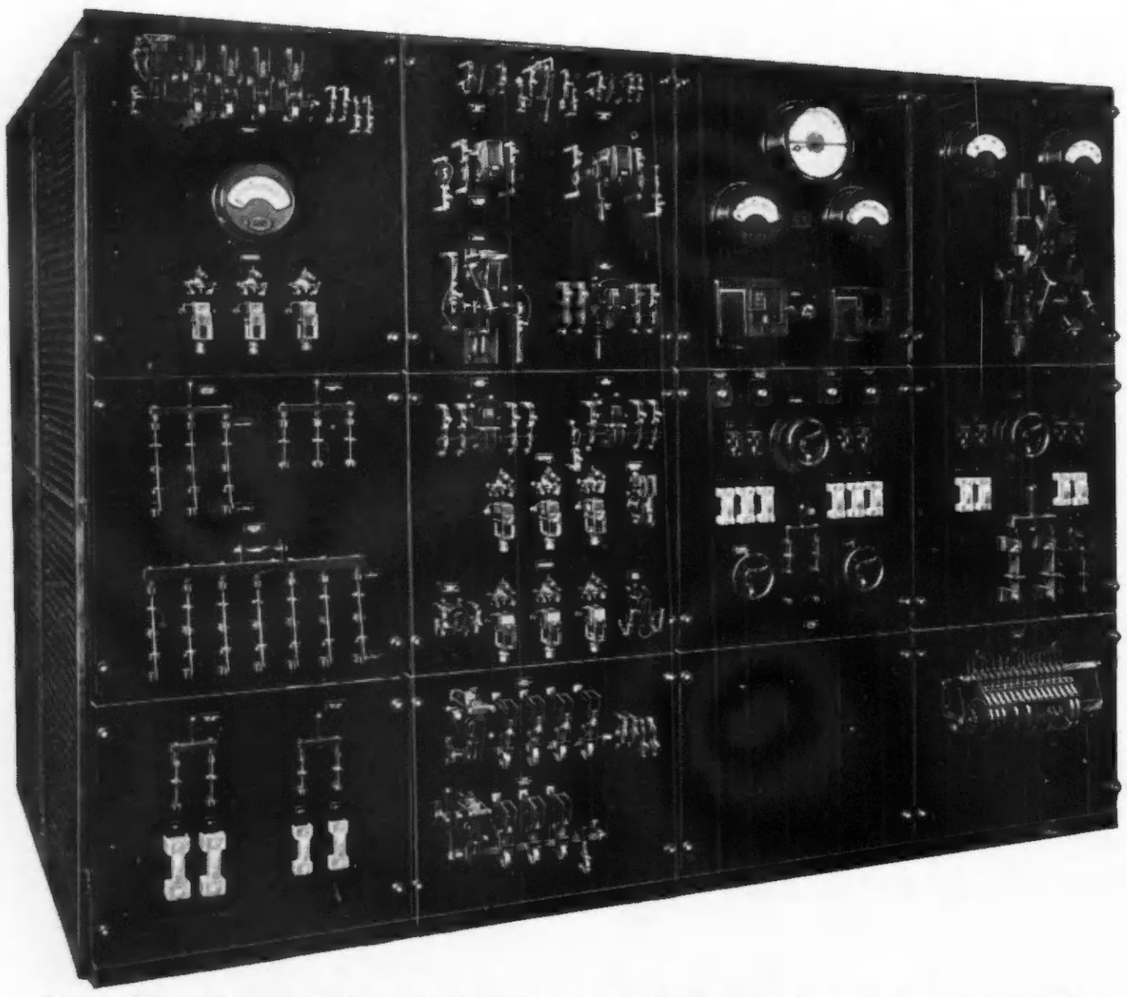


Fig. 32.—Control board for automatic standby power plant for railway signalling, for Fenchurch Street Station of the L.M.S. Railway.

ANTI-INTERFERENCE COILS.

Interference with radio reception on the part of road vehicles is stated to be caused, on occasion, by trolley buses. In order to obviate this trouble anti-interference coils have been designed which consist of a flat winding in parallel with which is a small adjustable condenser, the whole being mounted in a compact weather-proof case. These coils are tuned to the wave length of the principal transmitting station received in a district, the condenser being finally adjusted in the test room by making it part of a special testing set representing a wireless transmitter and receiver. Its design is such that following this adjustment its tuning can be relied upon to remain constant in spite of the rough treatment which it will receive upon the vehicle.

AUTOMATIC FREQUENCY CONTROL.

Further attention has been paid to the automatic frequency control of generating plant, with particular reference to its application to large interconnected power systems; in such cases control of the frequency greatly facilitates the correct division of load between different parts of the generating system. The frequency control apparatus which has been developed operates generally in the same way whether applied to a single machine or to a large system. The standard of reference is a master frequency clock exactly similar to that widely used for manual frequency control, except for the addition of contacts which generate impulses at two-second intervals, these impulses being supplied through the medium of suitable relays to a frequency controller, one of which is normally associated with each controlled machine. The controller operates in a simple way to compare the frequency time with the standard time and to correct any slight divergence that occurs by inching the governor motor of the turbine. The only addition to the normal turbine equipment is a "Twyntorq" motor which reproduces in the controller the governor setting and is used in the case of parallel operation of generating plant to form a basis for the loading of the machine with which it is associated. An extension of the system allows any desired sharing of the load between sets or stations to be obtained, or alternatively it maintains any desired loading on interconnecting lines between stations, whilst in each case the frequency of the whole system is maintained at the standard value. Fig. 31, shows the master clock and control panel for a turbo-alternator.

RAILWAY SIGNALLING STANDBY POWER PLANT.

With the introduction of electrical systems for operating railway signals a demand has arisen for standby power equipments which will come into

operation whenever a failure occurs on the normal supply. A number of automatically started petrol or diesel engine alternator sets for such service has been supplied. These equipments start up immediately a failure of the public supply occurs and the signalling supply is restored within about 10 seconds. If all signals were blacked out for 10 seconds traffic disorganisation would probably be caused, especially in congested areas. Attention has accordingly been turned towards developing a type of standby plant which will take over the load without allowing a dark period on the signal lamps.

The signal circuits are usually supplied with single phase alternating current at 600 volts and 110 volts, so that a standby storage battery by itself is not able suddenly to take the load. A storage battery, however, is made available by connecting it through a synchronous motor-generator set to the A.C. supply. Normally this motor-generator idles on the system, and is always kept running to trickle charge the battery. If the normal A.C. supply departs from the correct voltage and/or frequency by 10 per cent or more, relays operate to open the main supply switch and to weaken the field of the direct current machine of the motor generator set. This results in power being drawn from the battery and supplied to the signal circuits and the change-over can be effected immediately without failure of the supply feeding the signalling circuits. Since the standby equipment may be called upon to take the load for a considerable time it is not safe to rely on a storage battery only. A diesel-engine-alternator set is also provided and this is automatically started as soon as the public supply fails. When the engine set has run up to speed it automatically synchronises with the motor-generator set and the signalling load is transferred from the battery to the engine.

COLLIERY EQUIPMENT.

A new portable unit has been designed for underground lighting. It provides a 110-volt supply for lighting underground roads, crossings and haulage houses, and embodies a 5 kVA single phase, air cooled transformer having a voltage ratio of 400/110 volts, a double pole high voltage isolator with fuses and low tension air break circuit breaker equipped with overload trips and shunt trip coil together with the necessary protective relays and incoming and outgoing cable boxes. The complete unit is of flameproof construction and is approved by the Mines Department for use in fiery mines. Skids are provided to facilitate transport.

The transformer and the high voltage isolator are enclosed in a welded steel chamber on the side of which the low tension circuit breaker is mounted. At each end, high voltage cable boxes are fitted. Protection of the high voltage circuit is provided by means of specially designed fuses, which fit into two cylindrical bakelised paper holders. These fuses are capable of breaking 15,000 kVA at the rated voltage. The fuses are locked in position by a bolt bar which is so arranged that it is impossible to withdraw them unless the high voltage isolator is in the open position. The equipment is completely interlocked so that operation can only be carried out in the correct sequence.

The low tension connecting cable for this service is covered by the Maynard patents[7] and embodies two power cores, which are surrounded by a double screen, the outer screen being connected to earth while the inner screen forms a pilot lead. The cores of the connecting cable consist of tinned copper wire conductors insulated with one coat of pure and two of vulcanised india-rubber. The two cores are stranded round a cradle centre, which is filled and sheathed with tough rubber sheathing and screened with a concentric layer of tinned copper strands. Outside this is a further layer of tough rubber

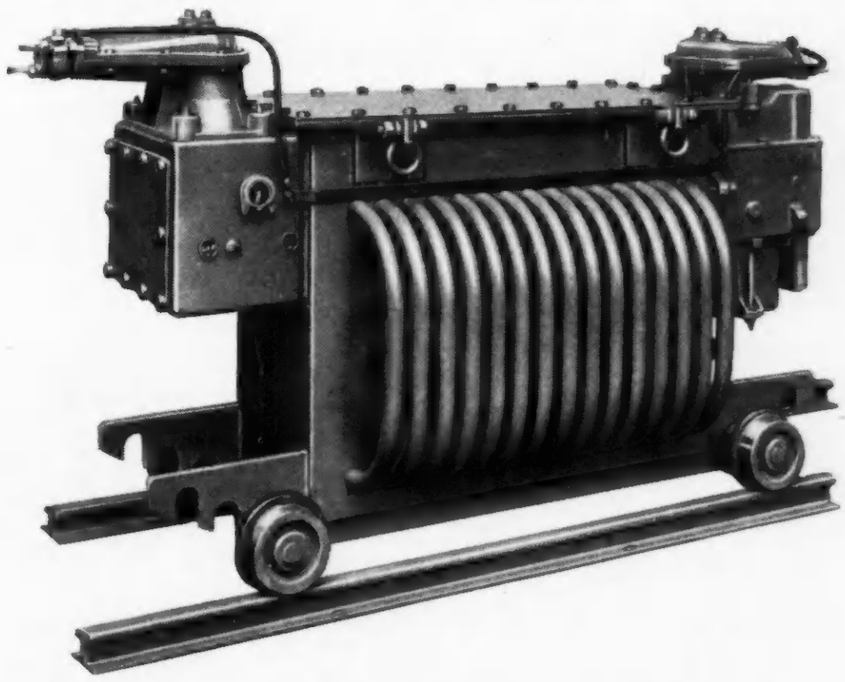


Fig. 33.—75 kVA portable mining substation, 3,300/440 volts, 3 phase, 50 cycles.

sheathing and tinned copper screening, the whole being sheathed overall with tough rubber.

The function of the double screen cable is to prevent any possibility of dangerous open sparking should the cable be pierced accidentally by a pick or damaged by shot firing. If the cable be pierced by a metallic object, the two screens are short circuited, thereby operating the relay which opens the circuit breaker before the main cores of the cable are reached.

Continuity of the earth circuit is an essential condition of operation, and any interruption in this circuit immediately trips the breaker. Earth leakage protection is also provided.

The cable is coupled to the equipment and to the coal face lighting fittings by means of 15 amp. 3 pin flameproof plugs which are so designed that when they are withdrawn the pilot circuit is opened

(7) Patent No. 382093.

first, thereby tripping the circuit breaker before the plug contacts open the main circuit.

Another development in equipment for use underground in fiery mines takes the form of a portable mining sub-station, fig. 33. This unit also complies fully with the latest Mining Regulations and consists of a 75 kVA 3 phase transformer having a voltage range of 3,300 to 440, with flameproof

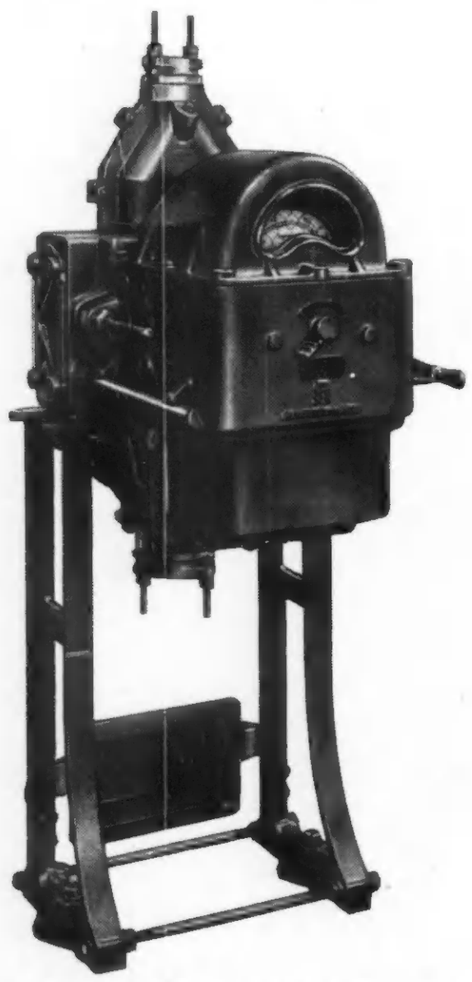


Fig. 34.—660 volt flameproof circuit breaker.

high and low tension switchgear and plug-in cable boxes. The equipment is provided with flanged wheels so that it can be moved readily on the tub rails. An important advantage resulting from the portability of the gear lies in the fact that long lengths of heavy low tension cable are avoided thereby simplifying distribution underground. The sub-station is particularly suitable for service near to the coal face as it requires very low head room, the overall height with and without cable boxes being only 3ft. 4ins. and 2ft. 10ins. respectively. In order to obtain these small dimensions the transformer core embodies five limbs.

An improved design of flameproof pedestal mounted oil circuit breaker, fig. 34, is available. It is rated to carry 150 amperes at 660 volts and has a rupturing capacity of 10,000 kVA.

HOUSE SERVICE SWITCHGEAR.

An interesting tendency in connection with house service switchgear lies in the demand for apparatus of the all-insulated type both for service cut-outs and main switch and fuses. This development constitutes the housing of the fuse or switch unit in a box of moulded bakelite or other insulating material. A 30 ampere house service cut-out trough and neutral link of this type have been produced recently, also a 30 ampere double pole main switch and fuses with interlocked lid, as shown in fig. 35.

TRANSFORMERS.

While no fundamental change has been witnessed in transformer practice the results of continued experimental work has led to much detailed improvement. Investigations have been completed relating to the heat developed under normal working conditions in transformer cores. The experiments have been made both with and without oil vents, and very interesting results have been obtained by plotting the relative isothermals and other data. The limits of core design have been defined with considerable accuracy, also the effect of oil ducts when adjacent to the edge or the face of the iron laminae.

Definite advance has been made in the production of an adequate specification for the paper covering of copper strip and wire. This important item in transformer manufacture has been thoroughly dealt with and a specification has been drawn up which covers all relative units. A specially designed machine has been installed at Pirelli-General Cable Works which makes it possible to adhere to the somewhat stringent specification which has been prepared.

STATIC CONDENSERS.

The design and processing of condenser spools for use for normal power factor correction and for high frequency electric furnaces has been thoroughly

Fig. 35.—Quick make and break switch and fuses in bakelite case.

investigated in the Witton Development Department and a new form of spool has been evolved in which, particularly for high frequency work, the losses have been much reduced and reliability and freedom from breakdown increased.

Research into the types and qualities of oil for use with oil immersed static condensers has proceeded. While transformer oils conforming to

British Standard Specification 148—1933 can be used for this purpose special oils are now available which are superior for the purpose in view. Such oils have very different characteristics—*e.g.*, as regards viscosity and iodine values, from those of class A and class B transformer oil.

ELECTRIC TRACTION.

While no extensive railway electrification scheme can be recorded during the year, evidence of continued progress in electric traction is afforded by several interesting orders for tramway, railway and trolley bus equipments. The Leeds City Transport Dept. have put in hand the construction of 16 new double deck tramcars, each fitted with four motors arranged to be connected in pairs in series across the line voltage. The motors are rated at 35 h.p. and are of special lightweight type.

A large contract for tramway motors has also been received from Glasgow Corporation Transport Dept., and comprises 85 sets of motor equipment, involving 170 lightweight tramcar motors of 50 b.h.p. capacity, together with unbreakable grid resistances and automatic circuit breakers. It is interesting to note that a large quantity of similar equipment has previously been supplied to Glasgow.

Fig. 37.—3,750 kVA remote electrically operated outdoor type feeder voltage regulator for 22 kV 3 phase 50 cycle line. To give minus 5% to plus 25% regulation in a total of 16 steps.

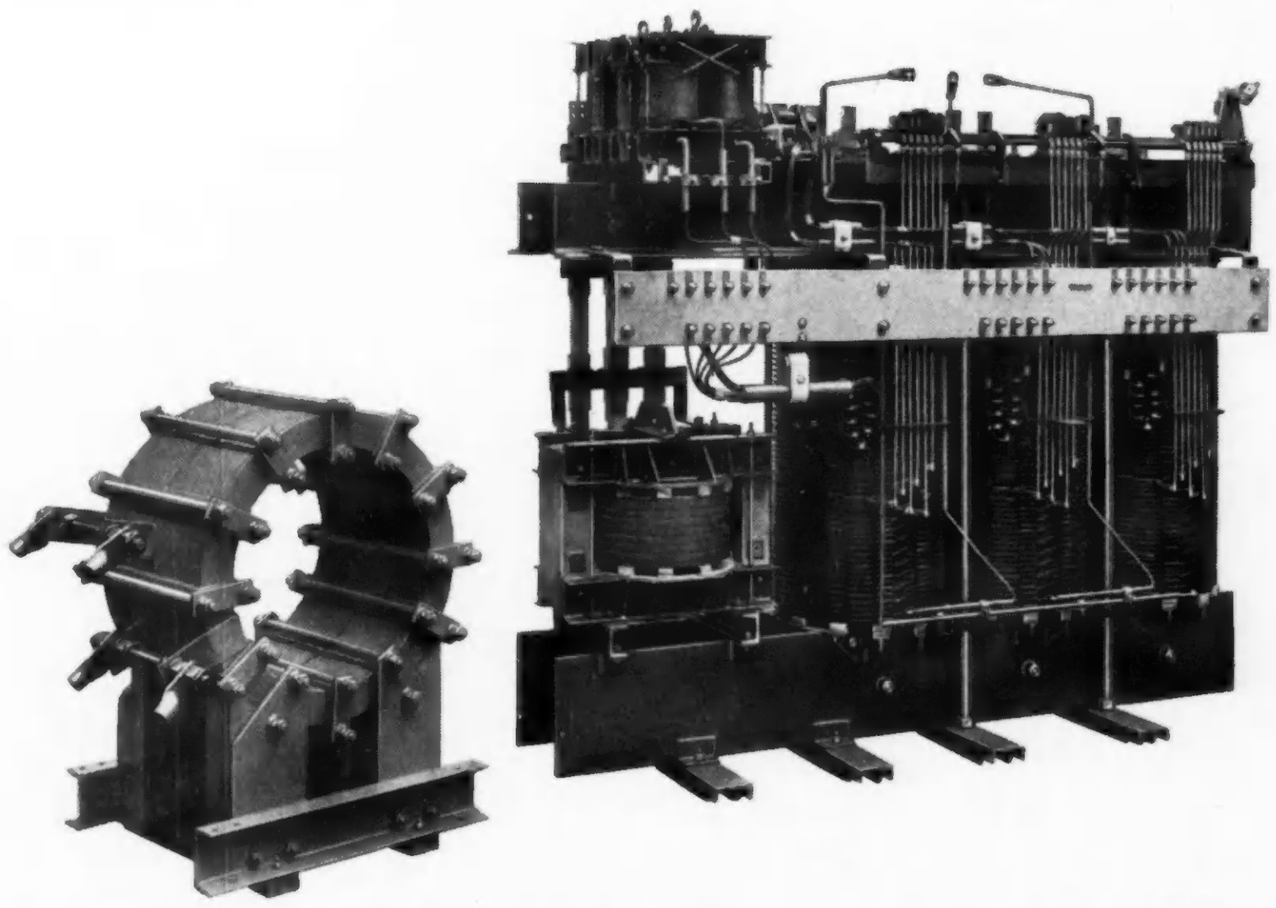


Fig. 36.—Transformer for 800 kW 540 volt mercury arc rectifier, showing interphase transformer and tapping switch chokes. A.C. supply, 5,500 volts, 3 phase, 40/50 cycles. On load and off-circuit tapping switches are fitted; also air cooled smoothing choke on left for D.C. side of rectifier.

An experimental installation of considerable technical importance has been applied to a new tramcar of the London Passenger Transport Board (L.C.C. Tramways). It consists of a regenerative equipment employing two 55 h.p. compound wound motors with the necessary control gear.

The equipment is required to give the same performance on the power side, both as regards speed and acceleration, as is obtained on the latest tramcars employing series motors. By a careful choice of the series and compound windings this requirement has been satisfied. At the same time, regeneration is available down to a very low speed, leaving very little braking to be done by rheostatic brake which is also provided and operates in conjunction with the standard magnetic track brakes. Each car is equipped with an over-voltage relay to protect the lighting circuits.

In the realm of railway traction one of the most important orders received has been for 50 motors each of 240 h.p. capacity, for the London Passenger Transport Board. These motors are identical in every respect with the 2,000

motors previously supplied to this authority.

Much progress has been made during the year in the design of trolley bus gear and two important orders have been obtained in conjunction with Leyland Motors Ltd. for the Corporation Transport Departments of Nottingham and St. Helens. For Nottingham 30 6-wheeler trolley bus chassis are being built to carry double deck bodies, the laden vehicle weight being 13 tons. Each equipment comprises an 80 h.p. regulated field motor together with the necessary foot-operated control gear, resistances, circuit breakers, skate, etc., while for St. Helens, eleven 4-wheeler trolley bus chassis are being supplied with electrical equipment similar to that for Nottingham.

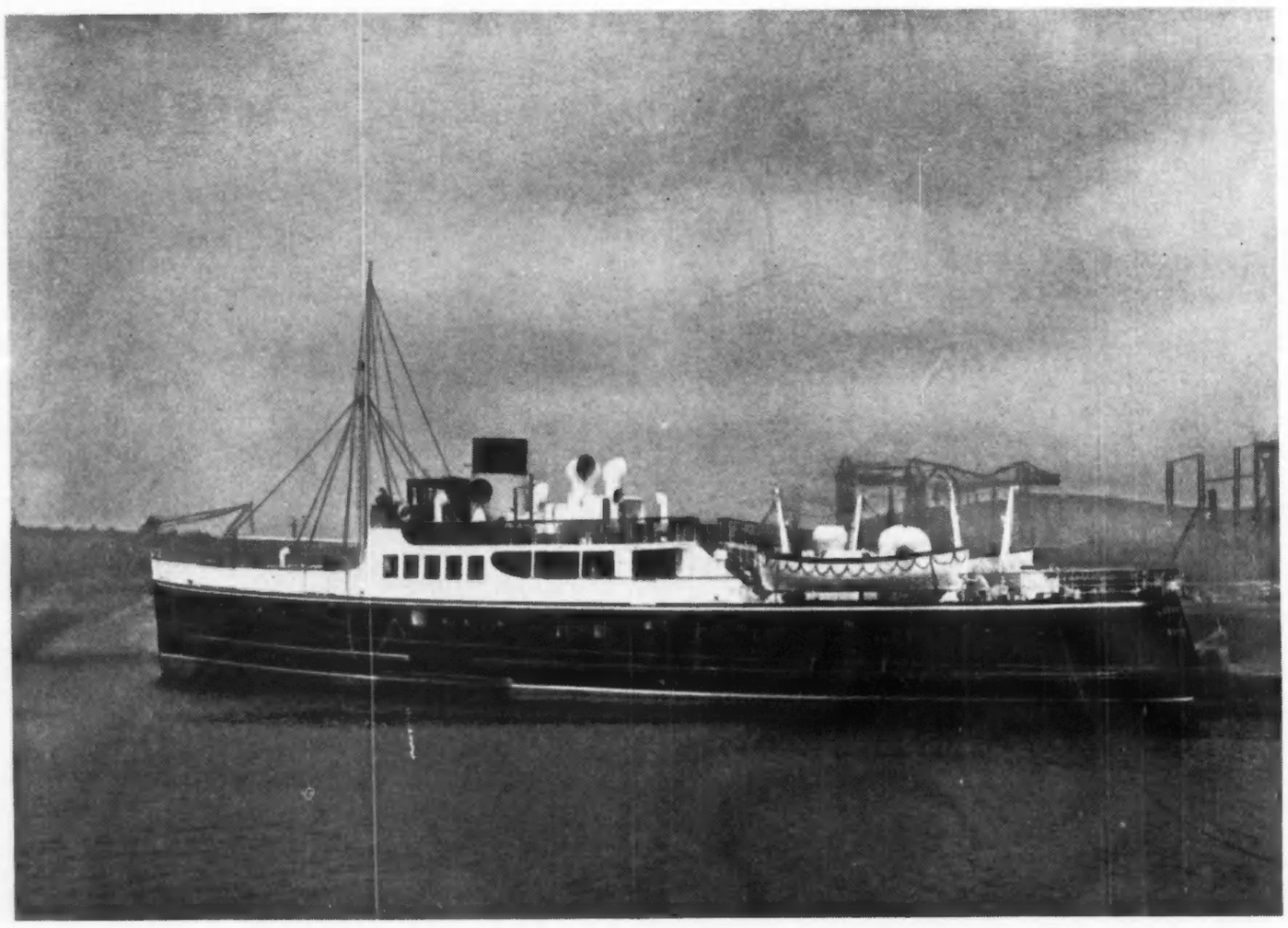


Fig. 38.—The Diesel-electric vessel "Lochnevis."

A development in the design of trolley bus equipment has been the production of a system of regenerative motor control which has many interesting new features.

In the ordinary system of regeneration the shunt or compound wound motor is controlled by a single controller which in the case of trolley buses is pedal operated. Each notch of the controller thus corresponds to the definite running speed of the vehicle; hence, any forward movement of the controller increases the speed, and conversely any backward movement produces regenerative braking and return of energy to the line. This feature tends against coasting.

In the G.E.C. "Independent" system two interlocked control drums are employed and two separate foot pedals, the one pedal being solely for the application of power, and the other solely for braking. By means of this second pedal are applied first, regeneration, subsequently rheostatic braking, and finally mechanical power braking, by compressed air, vacuum and the like. In the neutral position, when neither controller drum is being actuated, the vehicle is permitted to coast entirely free, thus providing a most valuable feature from a service point of view.

A cardinal feature, moreover, is that with this system the driver in braking the vehicle is compelled to use the regenerative brake, whereas with single pedal control he can, and does frequently, avoid the use of regeneration and brakes solely by the compressed air brake.

A demonstration vehicle has been equipped with apparatus constructed according to this system and the tests so far have been highly satisfactory. The fundamental principle of employing a separate pedal for braking has been commented upon very favourably by a number of authorities who have inspected the vehicle, as it is felt that this is both theoretically and practically the correct arrangement from the point of view of the driver of the vehicle. Practically all other road vehicles have this arrangement as for example, petrol-engine driven vehicles, and it has remained rather an anomaly that the electrically driven regenerative vehicle has hitherto employed only a single pedal for both accelerating and braking.

Leyland Motors Ltd. have evolved a new form of trolley bus chassis directed particularly towards obtaining an extremely low floor height. The design is such that there is only one step between the road level and the inside of the bus irrespective of whether a front or rear entrance is provided. The front entrance can be arranged at the extreme front of the bus so that the full length of the vehicle can be utilised for the accommodation of passengers. In the demonstration vehicle constructed, two 40 h.p. motors are arranged for series-parallel control. The motors are fitted at either side of the vehicle and each motor drives two wheels of the 4-wheel bogie, thus dispensing with the necessity of a central differential.

MARINE ELECTRIFICATION.

The outstanding event of the year in the marine world, so far as electrical equipment is concerned, was the completion and placing in commission of the Diesel-electric packet boat "Lochnevis" which was

fully described in the last issue of this Journal. This vessel incorporates a new principle in direct current twin screw propulsion. In a vessel embodying a direct drive on each of the twin screws, failure of one engine put the corresponding propeller out of service. In all electrically propelled twin screw vessels built prior to the "Lochnevis," failure of one engine resulted in a temporary failure of one propeller followed by a shut-down of the vessel itself pending a re-arrangement of the circuit connections.

On the "Lochnevis" however, arrangements have been made so that in the event of failure of an engine whilst the vessel is under propulsion, power for both propeller motors is automatically obtained from the remaining engine without total cessation of power on either propeller.

On the auxiliary side, plural starting equipments are becoming more widely used and marine engineers are realising the large amount of space which this system of starting affords, particularly in engine rooms where machinery is crowded together. A total of 12 plural starting equipments have been supplied to the Blue Star Line and New Zealand Shipping Co. The capacity of the system now available has been extended to include motors up to 100 h.p.

A new type of winch control equipment, adapted to give hoisting, derricking and slewing control has been evolved and installed on two coasting vessels.

Improvements to control gear include the redesigning of the small marine counter-E.M.F. starter so as to give a higher contact pressure on the contactors. All marine starters are now fitted with double pole breaking contactors to give complete isolation of the equipment they control.

HORTICULTURE.

During the past twelve months, considerable progress has been made in the application of electric soil heating, and the prospects of its wider use are much greater than was anticipated only a short time ago. A new development is that of fitting the cables with tails of V.I.R. insulated copper conductors, which not only effectively seal the cable ends, but also facilitate connection to the electricity supply. The provision of short lengths of cable with low loadings enables amateur growers to enjoy the benefits of a hotbed and there is little doubt that in this sphere alone there will be a considerable demand.

TURBINES.

A number of mixed pressure and back pressure turbines for driving generating plant have been installed in factories where pass-out steam for process work is required, also turbines for export to South Africa and Palestine have been built for coupling to the alternators mentioned earlier in this article. Turbo-blowers have been constructed for the new Corby Works of Stewart & Lloyds, Ltd., and other iron and steel works, while turbo compressors have been made for several North Country collieries and for a motor body works at Dagenham. All the turbo-compressors are of the

Fig. 39.—Loading part of a jaw crusher into an aeroplane for transport to the Cotabambas mine, situated at an altitude of 12,000 feet in an almost inaccessible part of Peru.

new Fraser & Chalmers inter-cooler type, which has proved very successful in operation.

MINING PLANT.

Of many complete mining plants exported to

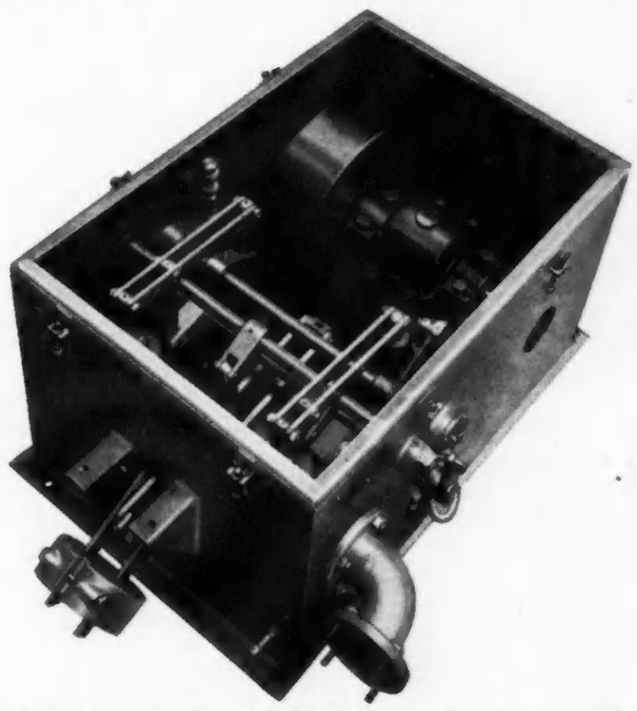


Fig. 40.—Semi-automatic brake control gear for winding engines.

various parts of the world, the most interesting was a complete crushing, milling and amalgamating plant with a capacity of 150 tons per day for the

Cotabambas mine, which is situated at an altitude of 12,000 feet in the most inaccessible part of Peru. About 600 tons of this machinery was conveyed for the last 60 miles to the mine by aeroplane, individual pieces weighing over 2 tons being carried over the intervening mountain range 15,000 feet high under the most arduous climatic conditions in approximately 30 minutes, a journey that would have taken 24 days by mule transport. Fig. 38, shows one of the pieces of machinery being loaded into an aeroplane. Other comprehensive mining plants include three for new properties in the Gold Coast area.

WINDING ENGINES.

In addition to the electric winder installation at Ryhope Colliery (described on page 51 of this issue), a number of steam and electric winding engines are being built for South Africa. Most of the electric engines will be fitted with a new semi-automatic brake control gear, which has been developed to prevent the deceleration of the winding engine from exceeding a predetermined maximum value, except when the cages or skips approach the end of a wind, thus leaving the braking force under the driver's control for smaller decelerations and during approach to bank and decking.

The control unit can be applied to double or single drum winders. It employs a brake governor driven from the drum or pinion shaft through machine cut gears, and consists of a flywheel driven through differential bevels between which is a pinion carried by a floating casing. As long as the speed of the flywheel is constant the casing remains stationary but any acceleration or deceleration causes a reaction between the bevel wheels, which is transmitted by the pinion to the floating casing causing it to rotate, and, by means of a gear segment and wheel, actuate a system of rods and levers.

This mechanism is connected to a controlling spring, which is arranged so that it is extended (whatever the direction of rotation of the winder) to a degree proportional to the rate of change of speed, and to a floating lever which controls an air or oil valve (according to the type of brake employed). When the rate of deceleration reaches a predetermined value, any further increase causes air or oil under pressure to be admitted to the brake engine and brings the brake under the sole control of the governor. When, however, the cage is approaching the end of a wind, cams, driven by the winder drum, render the deceleration governor inoperative so that the brake force is entirely under the control of the driver.

MECHANICAL HANDLING PLANT.

For loading coal into ships, etc., an efficient and easily controlled anti-breakage device has been designed; the coal is discharged by an inclined revolving distributor, electrically controlled, which deposits it without any appreciable direct fall and with very little segregation of sizes, thus reducing the overall breakage when reclaiming.

Of several coal and coke handling and screening plants installed, one of the largest is for a Chinese Railway Company. Large numbers of "Gyrex" and "Sherwen" screens have been installed in a wide variety of industries to handle almost every type of material; in particular, batteries of ten and twelve "Gyrex" screens have been installed in coke works.

COAL WASHING.

The "Chance" system of washing coal (sand flotation process) has now been in operation for over a year in a South Yorkshire Colliery and has given consistently good results within the stringent guarantees specified. Further plants are now in process of erection or have been completed in South Wales, fig. 41, at the hydrogenation plant of

Fig. 41.—"Chance" coal washing plant is installed by Fraser & Chalmers at The Ocean Coal Co., Ltd., South Wales.

Imperial Chemical Industries, Ltd., in a colliery in the Midlands, and in South Africa.

Considerable research work (based on the "Chance" process) has been carried out on a coal washer capable of cleaning fine coal, *i.e.*, coal below about 1/16" or 1/32". As a result, a combination of a fine coal washer and a de-watering machine has been developed. In the washer, sand is dispensed with, and the coal itself is used to produce its own fluid mass with excellent results. In the de-watering machine a scraper conveyor, the bottom plate of which consists of a very fine wedge wire screen, a small distance below the scraper bars, enables a bed of fine coal to accumulate and act as the filtering medium, giving a continuous process, which (on test) has delivered coal having about 20-25% moisture and discharge water practically free from solids. Capital and labour costs are much reduced compared with the older methods.

COILED COIL LAMPS.

The outstanding development in lamp manufacture during 1934 has been the production of the coiled coil lamp in the high voltage (200—260 volts) low wattage types of the general lighting service range. High voltage 40 watt lamps were marketed on September 1st, and high voltage 60, 75 and 100 watt lamps soon afterwards.

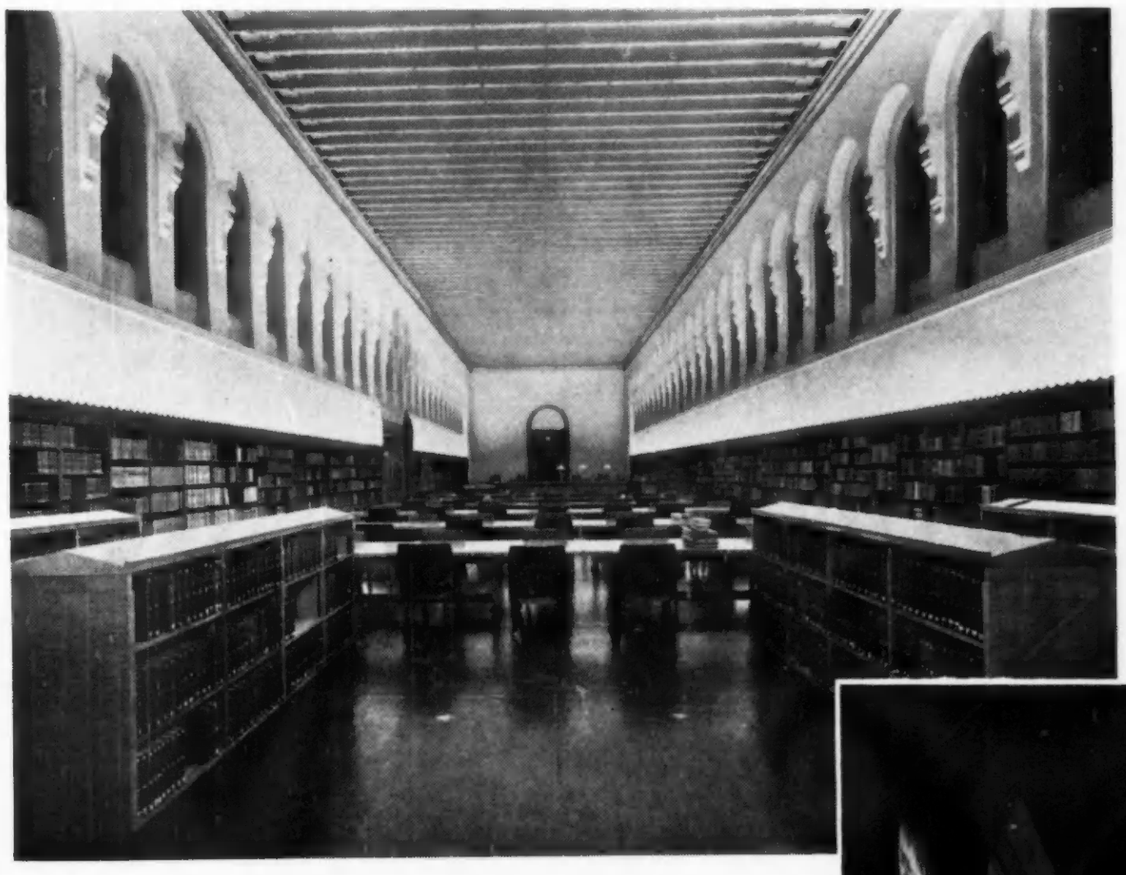


Fig. 42.—Lighting of the Reading Room in Cambridge University Library.

These lamps give the following increase in light output over and above the corresponding lamp of single coil design :

High voltage 40 watt .....20 per cent.
„ „ 60 „ .....15 „
„ „ 75 „ .....12½ „
„ „ 100 „ .....10 „

This achievement may be regarded as the greatest advance in lamp making technique during the last twenty years.

The following brief description of the principles governing the manufacture of gasfilled incandescent electric lamps will show how the development of the coiled coil lamp was achieved.

By filling the bulb of a straight wire cage-filament lamp with an inert gas to a definite pressure, normal filament evaporation is suppressed and it is possible to run the filament at a higher temperature for a given life. In these circumstances however, the energy lost in the gas will more than offset the gain in light output due to higher filament temperature, and the efficiency of the lamp in lumens per watt will be less. Langmuir found that by coiling the filament wire into a closely wound spiral so as to reduce the area of filament exposed to the gas he was able to reduce the watts lost in the gas to such an extent as to produce a gain in lumens per watt.

The coiled coil lamp is merely an extension of the original idea conceived by Langmuir, in that the single coil filament is once again coiled so as to reduce still further the area of filament wire exposed to the gas and thus secure a further gain in lumens per watt.

These principles can be applied readily to fairly stout filament wire having mechanical stability, but difficulties occur when they are applied to very fine wire of considerable length, and it is only during comparatively recent years that improvements in the production of suitable tungsten wire, relating to its coiling and heat treatment, have made it possible to produce single coil gas-filled lamps in the high voltage low wattage types.

In the coiled coil filament the primary coiling is done on a much smaller mandril than that which is used for the single coil filament and

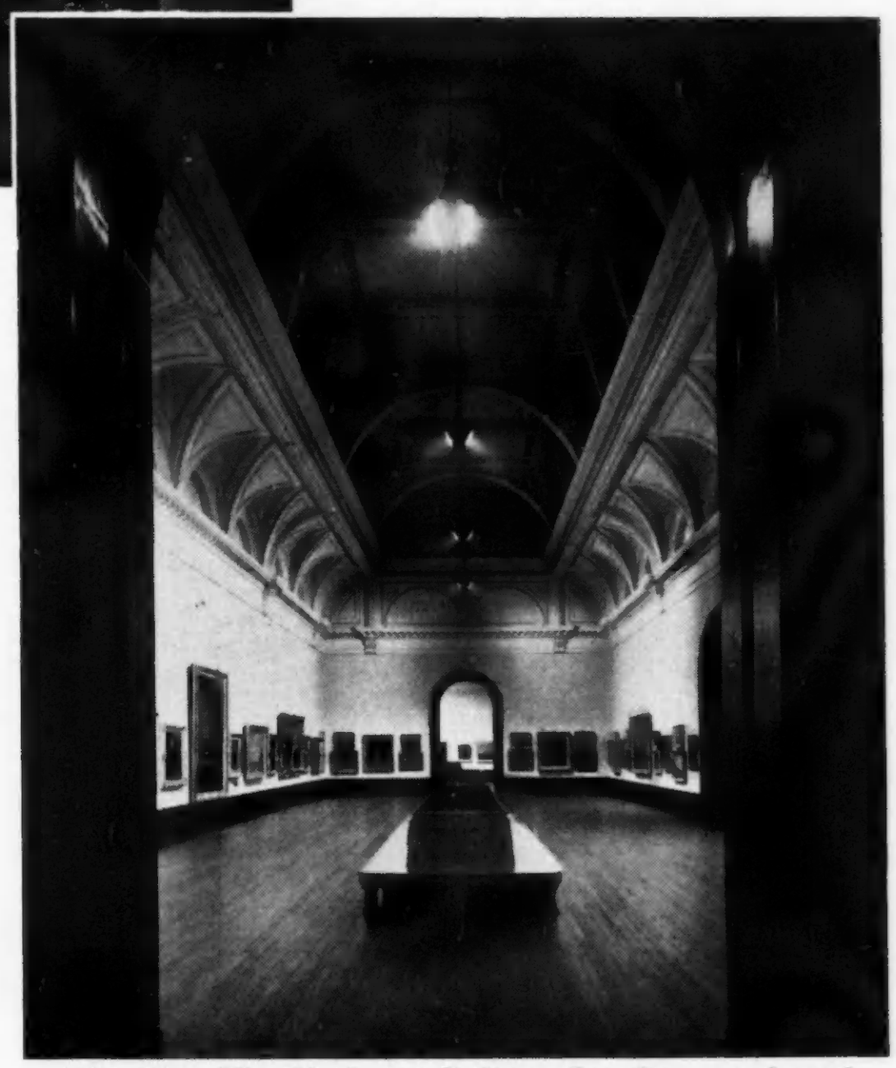


Fig. 43.—The National Gallery, London, equipped with special art gallery lighting fittings.

the mandril used for the secondary coiling is much larger by comparison. This is necessary in order to increase the mechanical stability of the coiled coil filament so that it meets the conditions of ordinary service; but the result is the same, in that the overall length of the coiled coil filament is considerably shorter than that of the single coil, thus reducing the watts lost in the gas.

There are nearly three times as many primary turns in the coiled coil filament as there are in the

single coil filament of the same watt rating. This is due mainly to the smaller mandril, but not wholly so, as part of the increase is due to the fact that a longer length of straight wire is coiled to consume the watts saved in the gas; thus with the same wattage consumption and the filament operating at the same temperature as in the case of the single coil lamp, increased light output is obtained in proportion to the length of straight tungsten wire added to the coiled coil filament.

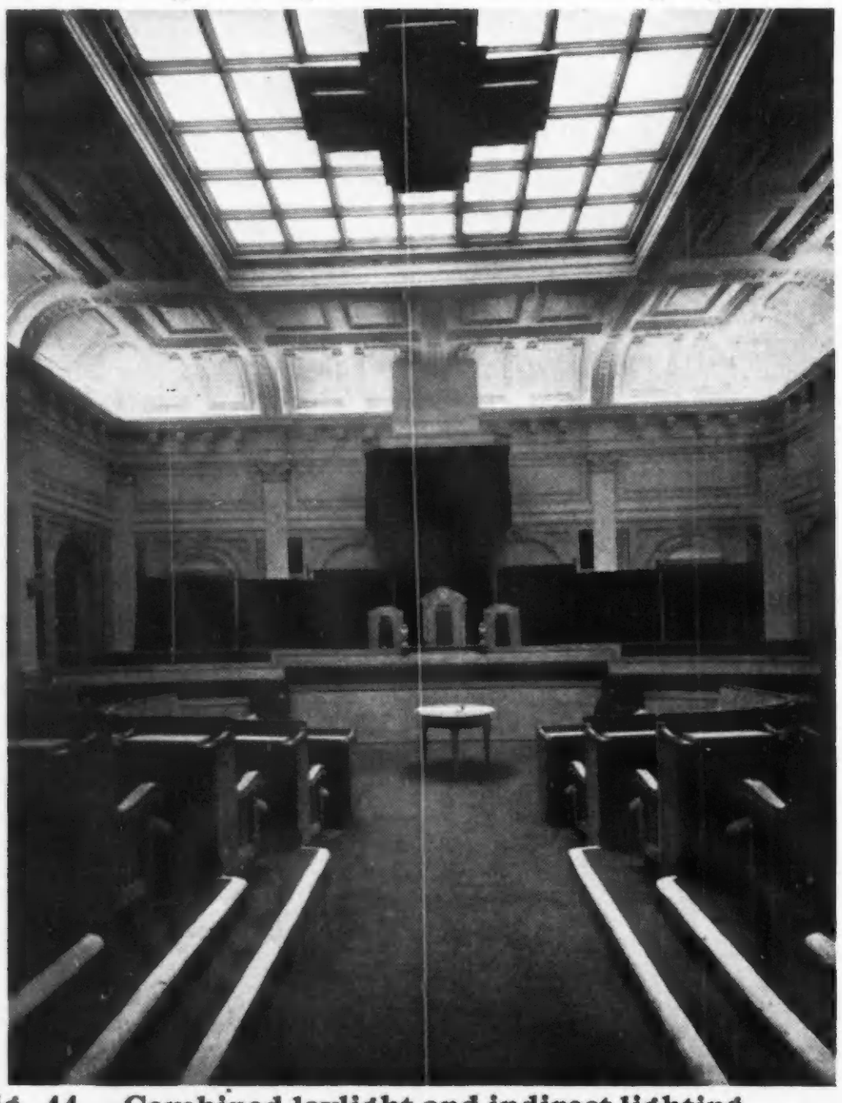


Fig. 44.—Combined laylight and indirect lighting in the Council Chamber, Camberwell Town Hall.

Many difficult problems were met with in developing the high voltage, low wattage coiled coil lamp. First there was the problem of producing tungsten wire with the necessary characteristics, namely, that it should be capable of coiling on very small mandrils and respond to the heat treatment for mechanical stability, and it has to be borne in mind that stabilisation must be carried out at high temperature with the coil still on the mandril. Owing to this necessity, steel mandril wire had to be abandoned in favour of molybdenum.

In addition, new machines had to be provided for secondary coiling; also special plant had to be installed for heat treating filaments on the mandril, as the old fashioned method of heat treatment was too slow for mass production. Again, machines for automatic mounting of the filaments had to be specially designed.

Another problem which had to be solved related to high voltage coiled coil lamps. Owing to the reduced space between the lead-in wires, an arc struck between the broken ends of filament on failure of the lamp may extend to the leads and assume disastrous proportions if some device is not provided within the lamp to prevent this. A preliminary survey of the question would suggest the incorporation of a fuse of light calibre within the cap of the lamp, which would function before the local fuse had time to operate. In practice however, it was found that the fuse itself would frequently start an arc within the cap which would assume disastrous proportions, especially where earthed holders are used. Considerable experimental work led eventually to the use of insulated (actually glass lined) caps and long double fuses which can be absolutely relied on to function with safety. Patents have been applied for to cover this design.

Finally, a new manufacturing technique had to be devised in order that coiled coil lamps should be made with that same uniformity of performance and rigid adherence to modern specification which characterise other types of Osram lamps.

It should be added that the processes of manufacture of coiled coil lamps are covered by a number of patents owned by the G.E.C.; other applications are pending.

AUTOMATIC CUT-OUT DEVICE IN DECORATION AND SIGN LAMPS.

The process of locating the lamp responsible for the failure of a series circuit may prove difficult, particularly in cases where decoration lamps are used. To meet the difficulty, a device based upon a new principle is being incorporated in Osram decoration and sign lamps.

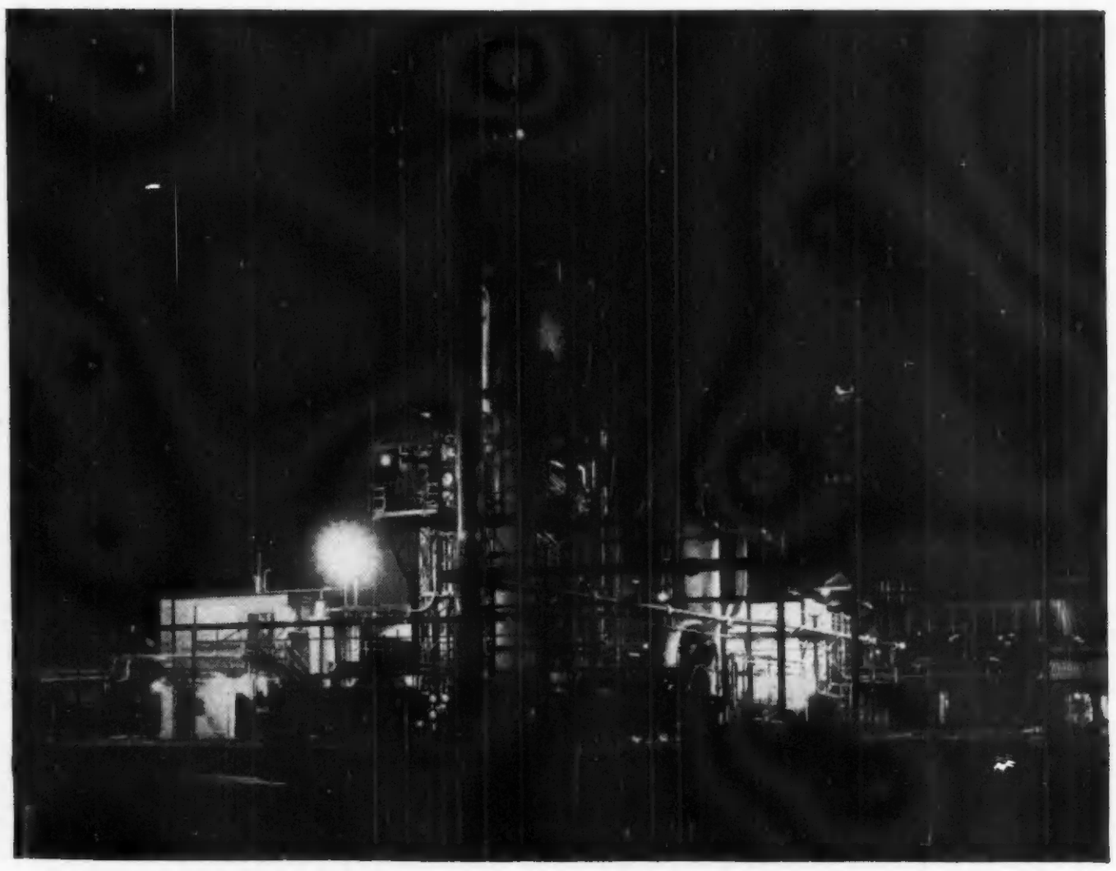


Fig. 45.—Floodlighting at Lobitos Oil Refinery, Ellesmere Port.

The general principle underlying all devices hitherto employed has been to incorporate in each lamp a circuit in parallel with the filament, so designed as to carry no current while the filament

is intact. As soon as the circuit through the filament is interrupted, however, the parallel path comes into operation and the remaining lamps of the series continue to function; thus the lamp which has failed can be detected easily and replaced.

The choice of short circuiting device is largely dependent upon the applied voltage of the series circuit and the lamp rating; in the case of high voltage traction circuits, an oxidised aluminium strip, having a breakdown potential of 200—300 volts, has been successfully adopted, but this method has proved unsatisfactory for circuits of from 100 to 250 volts, owing to the difficulty in controlling the deposition of the thin oxide film necessary for breakdown at these potentials.

Series decoration or sign lamps, operating on normal lighting circuits, call for an insulating medium which will break down at voltages of from 80 to 100, but permanently retain its insulating properties at the lower voltage of the lamp rating. The most suitable medium has been found to be a metal core of tungsten, molybdenum or nichrome coated with a thin film of sodium tungstate, more commonly referred to as "tungsten bronze" on account of the colour of the tungstate.

The breakdown potential of the layer of sodium tungstate is dependent upon various factors such

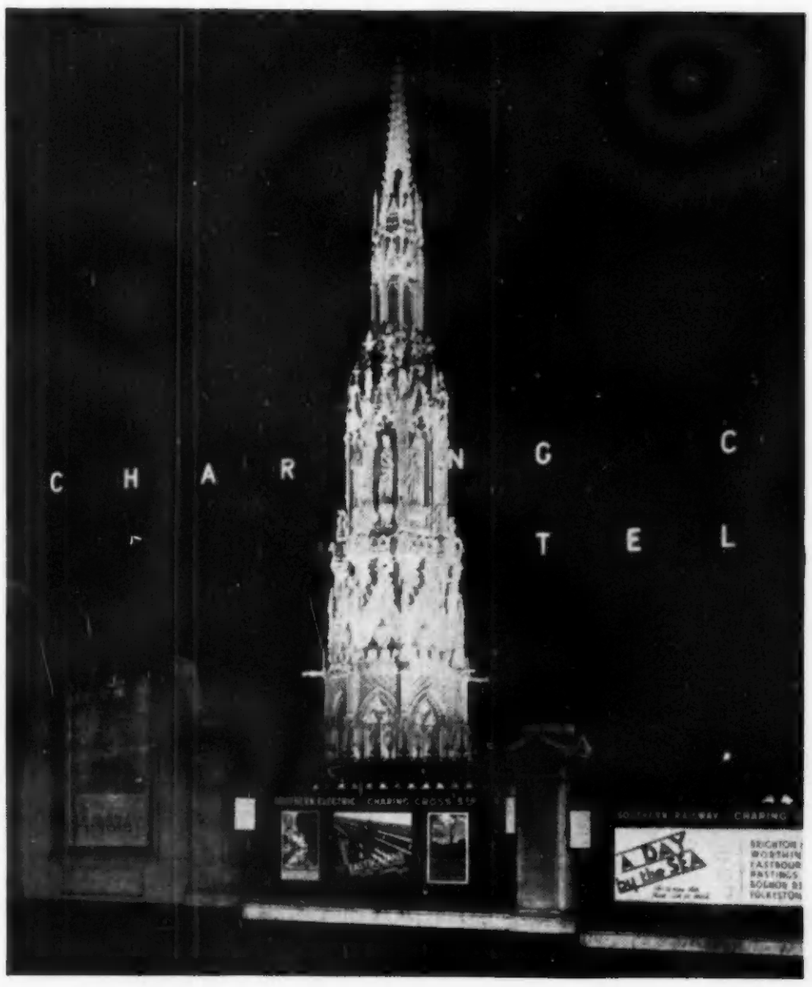


Fig. 46.—Eleanor's Cross, Charing Cross, London, illuminated by floodlights.

as chemical composition, temperature of the treating bath and time of immersion in the fused tungstate. All these points have to be carefully controlled in order to ensure a coating which will breakdown uniformly on low voltage circuits upon failure of the lamp.

A short length of this "tungsten bronze" wire is connected in parallel across the lamp filament, as shown at fig. 47. One end of the "tungsten bronze" wire is connected to the centre contact of the lamp cap while the other is enclosed within a coil of aluminium wire connected to the cap shell.

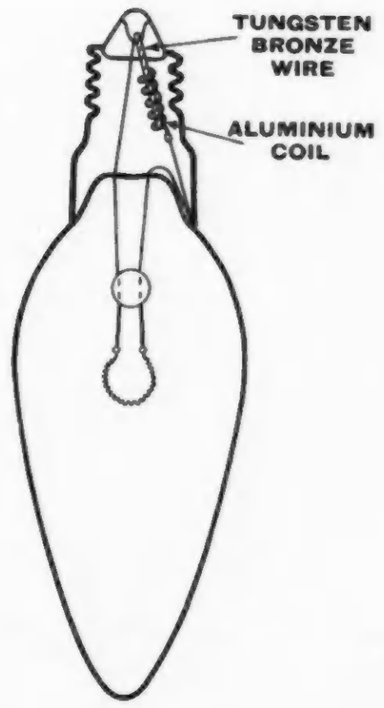


Fig. 47.—Automatic cut-out device embodied in decoration and sign lamps.

The process of soldering the tungsten bronze wire to the centre contact breaks down the insulating medium; it is therefore obvious that only one end of the tungsten bronze wire can be soldered to any metallic parts of opposite polarity. The function of the aluminium wire coil is, therefore, to make mechanical contact between the tungsten bronze and the cap shell without injury to the insulating film.

Soft aluminium wire is chosen for this purpose, as it does not "spring back" on coiling and therefore retains good mechanical contact with the tungsten bronze. Contact between the aluminium wire and the cap shell is made with a short length of copper wire.

While the voltage across the junction between the tungsten bronze wire and the aluminium coil remains low, no current will pass but as soon as the full voltage of the circuit is applied, the insulation breaks down and the cut-out functions.

PHOTOFLOOD LAMPS.

A new photoflood lamp has been designed to give a high intrinsic brilliancy and efficiency of 33 lumens per watt for a life of approximately two hours; it is fitted with the latest type fuse as used in the high voltage low wattage coiled coil lamp and is a valuable addition to the lamps available for indoor photography.

It differs from its predecessors in that the wattage consumption is 275 instead of 200; it is

supplied in a smaller bulb, viz., one of 65 mm. diameter, and 117.5 mm. overall length. These dimensions are the same as those of the standard 60 watt pearl lamp and so the new lamp can be used in any existing fitting.

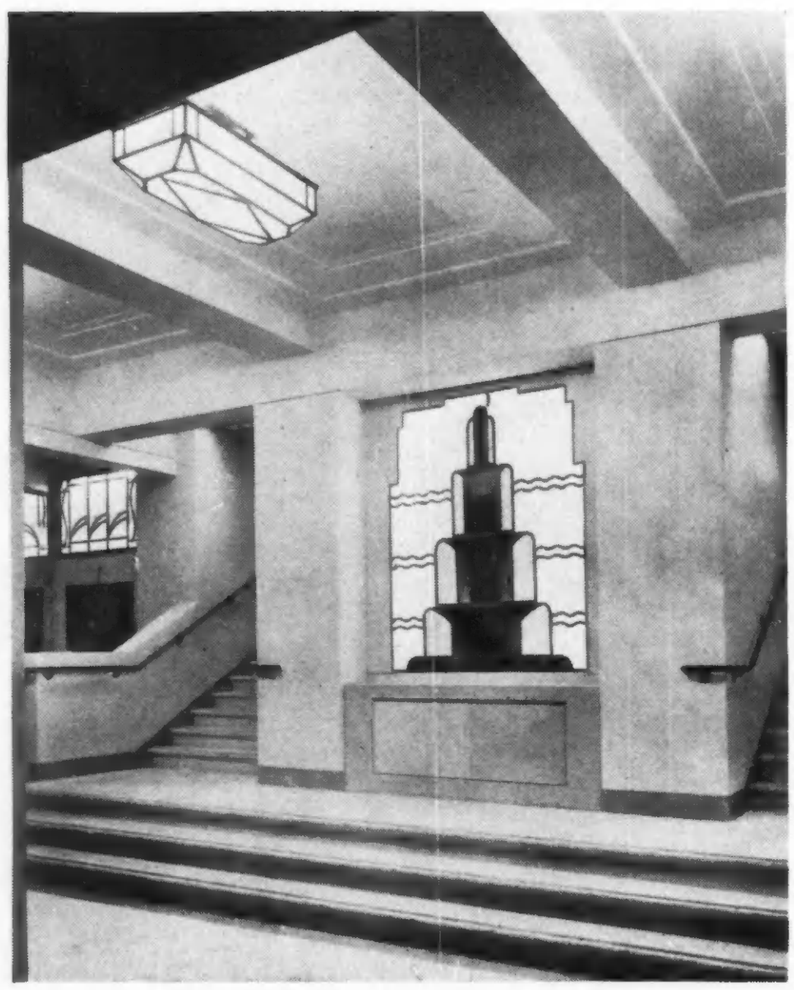


Fig. 48.—Built-in architectural lighting features at Leyton Corporation Baths.

DECORATIVE ILLUMINATION.

In the field of decorative illumination, architectural lighting maintains its appeal to architect and client, and the introduction of the architectural lamp has extended the scope of this particular form of lighting owing to its suitability for schemes requiring a continuous line of even illumination in various geometrical forms.

The ultra-modern tendency in design is giving place to a more restrained and dignified decorative treatment which has a wider appeal and lends itself more readily to adaptation to modern standards of illumination which call for lighting of the right quality and intensity.

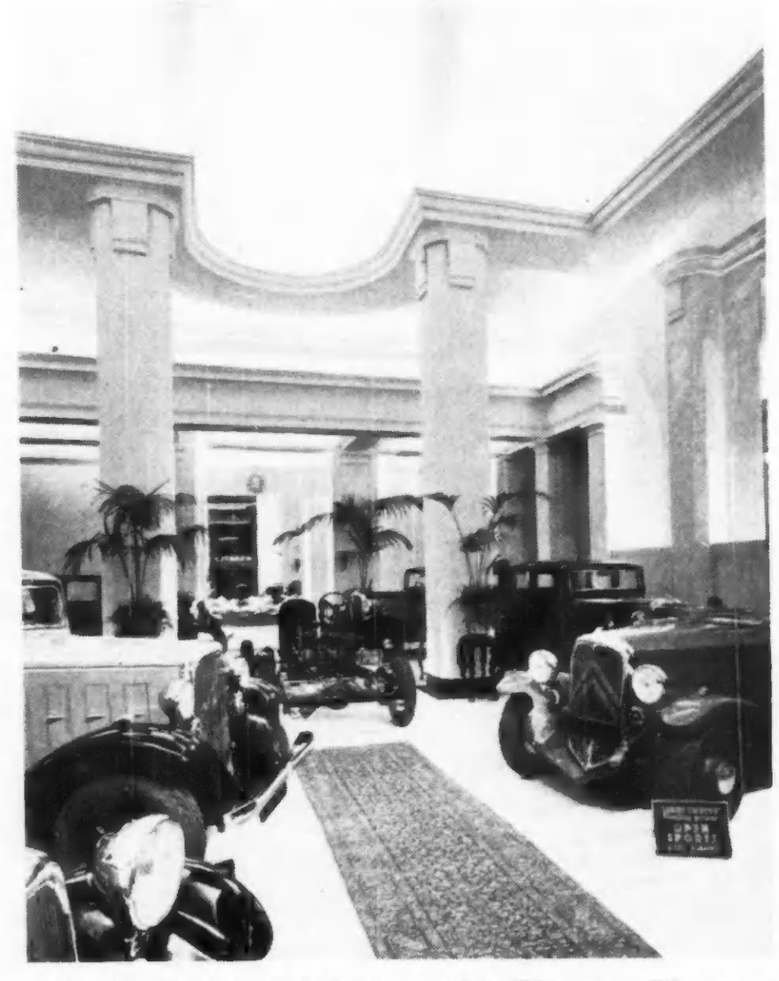


Fig. 50.—Indirect lighting at the Citroen Showrooms, Piccadilly, London.

Fig. 49.—Luminous decorative troughing at Harrod's Stores, London.

Glassware still predominates as a decorative material as well as a light diffusing medium, metal work being used mainly for structural requirements. This tendency is revealed in standard domestic lighting units, some of which lend themselves to application as architectural motifs and nearly all depend for effect upon line and form, rather than upon decorative detail.

Indirect lighting has also increased in popularity. In the domestic lighting market, this has expressed itself in a demand for indirect pendant lighting units in which some luminous feature is embodied to give decorative effect in conjunction with the reflected light on the ceiling.

The largest single lighting fitting ever produced in the works of the G.E.C. has been manufactured for despatch to South Africa for installation in the new Pretoria City Hall. This fitting, which measures 12 feet in diameter and weighs 2 tons, is equipped for lighting in white and in three colours. The loading for the white lighting alone is over 22 kilowatts with provision for a similar loading of coloured lighting.

Mention should be made of a decorative glass unit for installation out of doors, round flower beds or along garden paths. Another unit for underwater purposes has been designed to take a clear or coloured lamp up to 40 watts. It is very suitable for ornamental pools or fountains.

LIGHTING OF SHOPS AND OFFICES.

The development of diffusing glassware of British manufacture has been continued, and considerable attention has been paid to the question of reliability of such glass under extreme heat. In order to ensure that diffusing glassware fittings will operate in service without risk of failure from cracking, the G.E.C. Research Laboratories have been investigating thermal shock tests which can be applied to such fittings. A bathing test has been devised which it is hoped will ensure that both the design and the quality of glass are such that the fitting will not crack under normal service conditions. A new diffusing glass unit of extremely high efficiency has been introduced, the features of which are (1) a silvered mirror trough which reflects a large proportion of the light which would normally strike the ceiling and re-directs it on to the working plane; (2) an interior graded sprayed cylinder which reduces surface brightness at all angles at which the fitting would normally be viewed without interfering with the high transmission in other directions, and (3) a special decorative canopy which, at the same time, performs the function of protecting the current leads from overheating.

Another unit for use in small offices or for kitchens, bathrooms and the like, is the opal Coolicon fitting, which is made in a range of four colours and in two sizes, and is designed to substitute something of pleasing appearance and good light distribution characteristics for the ordinary opal conical shade which in the past has been the only fitting available where something really cheap was required. The opal Coolicon unit, in addition to providing a far more efficient and pleasing fitting at relatively small extra cost, also embodies features protecting the current leads from overheating.

The range of Gecoray mirror glass reflectors has been considerably increased by the addition of units for show case lighting, demi-coup bracket indirect lighting, and several units suitable for either direct or indirect illumination. Special laboratory work has been applied to the design of efficient diffusing flutes for these reflectors. The new type of fluting provides adequate diffusion so that striations are obviated with a negligible loss of light due to internal or cross-reflections.

HOSPITAL FITTINGS.

New lighting fittings include two ranges for use in hospital wards. One of these comprises a number of fittings manufactured in Roanoid, a substance which lends itself to easy cleaning. In many cases,

Fig. 51.—The lanterns in the Royal Arcade, London, are fitted with special reflectors to concentrate light on to the footway.

all projections such as gallery screws which might harbour dirt have been entirely eliminated.

The other range of fittings comprises some opal glass and chromium fittings of novel design arranged

Fig. 52.—Dual purpose lighting fittings in the wards of the Royal Free Hospital, London, provide local illumination without discomfort to patients in adjacent beds.

in such a way that either over the beds or down the centre of the ward, lighting can be supplied locally from a lamp concealed in a chromium tube

so that no light can possibly get into the eyes of the occupants of adjacent beds, fig. 52.

INDUSTRIAL LIGHTING.

In industrial lighting, the outstanding development of the year has been the progress made with the Osira lamp for interior illumination. Practical tests have proved conclusively that apart from the very high efficiency of the lamp as compared with tungsten filament lamps, the Osira lamp by reason of the quality of its light, is particularly suitable for very many industrial situations. Under its light, sharper definition and increased visibility are obtained.

Fig. 53.—Osira lighting in the foundry of Leys Malleable Castings, Ltd., Derby.

Fig. 54.—Osira lamps and fittings illuminating a coal-picking belt at Shireoaks Colliery near Nottingham.

A range of vitreous-enamelled reflectors has been produced for use with the 250 watt and 450 watt Osira lamps. For each of these sizes of lamp three types of reflector are available; they are specially designed to make the most practical use of the new light source. The first type of reflector is shallow and gives a wide distribution; the second is a deep reflector giving a cut-off 20 degrees below the horizontal with a dispersive distribution, and the third is a 45 degree angle reflector for side mounting.

For interior use these reflectors are fitted with an easy wiring detachable top designed to protect the current leads from heat. When used for exterior purposes provision is made for the lamp to be enclosed in a heat resisting well glass. The form of the cast top prevents the entry into the fitting of any condensed moisture from the supporting brackets.

A range of reflectors and glasses for use with screw top porcelain fittings has been extended. In addition to providing dispersive and angle reflectors for use with the standard well glass fittings of this type, two totally enclosed single piece mirror glass reflector units have been designed for use with the same tops. These reflectors are based respectively on the 200 watt Gecoray floodlight reflector and the 200 watt P.L.A. reflector and give corresponding concentrated and widely diffused beams. Such fittings are particularly useful in places where any vapours, fumes or condensed moisture are present which might attack a metal fitting, or for situations where the atmosphere is loaded with dust whether of an inflammable nature or not.

Flameproof fittings to comply with H.M. Mines Department's requirements have been introduced during the year, while an interesting development in this class of lighting is the introduction of an oil filled inexplodable fitting. The feature of this fitting is that the well glass in which the lamp is placed is filled with a non-inflammable transparent oil to such a depth that, even if the lamp bulb bursts and the oil rushes into the evacuated space, the oil level will still remain above any part of the lamp or lampholder at which sparking might occur.

SPORTS LIGHTING.

Considerable progress has been made in the investigation of the lighting requirements of various sports and special reflectors have been produced to meet the peculiar requirements. This matter was dealt with fully on a recent occasion in this Journal.[8]

(8) G.E.C. Journal, Vol. V, No. 3, p. 175.

FLOODLIGHTING.

Further progress has been made in Osira electric discharge floodlighting. The outstanding developments are (1) the marked improvement in efficiencies of the lamps originally put on the market and (2) the introduction of a sodium lamp unit. Possibilities of floodlighting with the high pressure mercury lamp have also been exploited during the year with striking results.

The use of tungsten lamp floodlights for industrial purposes has progressed, outstanding installations being the Lobitos Oilfields new refineries in Cheshire, fig. 45, the floodlighting of Grimsby Docks and Coaling Wharves, and of railway goods yards and sidings.

Another aspect of floodlighting that is daily proving more popular is the use of floodlights for underwater illumination in baths. Several systems have been employed, the latest being one which spreads a fan of light below the water level, thus eliminating the tendency towards shafts of light which, in the opinion of many people, mars the appearance of the earlier installations.

EXTERIOR LIGHTING FITTINGS.

As in the case of other classes of lighting fittings, street lighting fittings have been designed suitable for utilising to best advantage the qualities of the Osira electric discharge lamp.

A single-piece diffuser-refractor has been developed which gives a performance comparable with that of the Watford and Lewisham lanterns. The new unit provides a simple method of converting existing Wembley Lanterns as used with 300/500 watt filament lamps for use with Osira lamps. The refractor combines on the one piece of glass concentrating prisms and diffusing flutes which provide the main beams from the unit. This patented combination has the effect of spreading out the brightness over the whole side of the refractor and so minimising any chance of glare.

A simple diffusing globe for the Osira lamp has also been designed. It is so shaped that the projected area in various directions produces a polar curve of maximum intensity at about 60 degrees to the vertical and with an adequate intensity in the downward direction. This unit produces good results for the diffused lighting of areas such as road intersections, yards or parks where symmetric distribution and good appearance is required.

An improved patented type of external connecting box has been evolved for use with lanterns using Osira lamps and extended also to the Wembley Lanterns for 300/1500 watt Osram lamps. This connecting box is arranged to preclude any chance whatsoever of water entering a pendant street lighting lantern

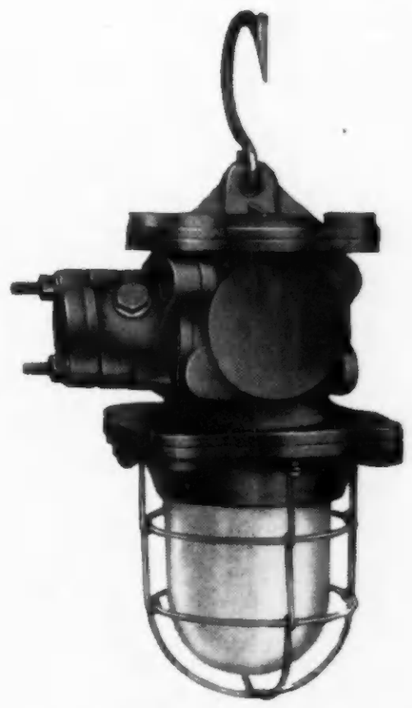


Fig. 55.—100 watt flameproof lighting fitting.

whether from the outside or through the bracket arm and should obviate lamp breakages due to water drip.

AERODROME LIGHTING.

Landing Floodlights.

The past year has witnessed many developments in the design of aerodrome and air-way lighting equipment, a full description of which appeared recently in this Journal.[9]

Fig. 56.—Walthamstow stadium speedway illuminated by speedway lighting reflectors.

(9) G.E.C. Journal, Vol. V., No. 4, p. 245.

For small aerodromes where, owing to financial reasons or due to the scarcity of air traffic, it is imperative to keep down to a minimum first costs for the installation of aerodrome lighting equipment, only one fixed aerodrome landing floodlight is used. This is placed near to the electric supply so as to avoid the use of long cables. When, owing to the direction of the wind, the pilot has to land in the face of the floodlight, dazzle is prevented by landing in the shadow caused by a movable bar in front of the floodlight. This is known as the shadow bar system. The advantage of this system is cheapness; its disadvantages are that a good landing depends on the correct actions of two people—one in the air and the other on the ground moving the shadow bar. Further, it is always necessary to have an operator at the floodlight whenever an aeroplane is landing. A shadow-bar floodlight has been designed which has the same efficient optical system as the standard type of 9 kW 9-lamp aerodrome landing floodlight, but employs three 3 kW lamps with reflectors placed vertically one above the other. These are enclosed in a vertical cylindrical housing constructed of brass and copper and fitted in front with sliding half cylindrical glass doors, the whole being weather-proof and dust-proof.

The arrangements for focussing the lamps and tilting the reflectors are similar to those of the 9-lamp floodlight and practically the same maximum beam candle power of 1,200,000 is obtained. The light distribution curves are almost identical except that the horizontal divergence is not quite so wide.

The shadow bar is constructed of sheet metal and is attached to a 3ft. diameter ring which is pivotted on ball bearings at the top of the floodlight. The operator stands on a platform at the back of the floodlight and keeps the aeroplane in shadow by steering the ring. The width of the shadow is about 36ft. at a distance of 500ft. from the floodlight.

This floodlight may also be used as a beacon and for such cases is equipped with a $\frac{1}{2}$ h.p. motor with clutch and gearing inside a cast iron base. When operating as a beacon the shadow bar is folded and clamped against the side of the housing which is then revolved by the motor at a speed of 11 r.p.m. Simultaneously, the mirrors are tilted upwards so as to give the correct light distribution for a beacon. It is interesting to note that an apparatus of this type installed by the G.E.C. at Dum Dum, India, evoked very favourable comment from competitors in the recent England—Australia air race.

Illuminated Wind Direction Indicator.

Improvements have been made to the illuminated wind direction indicator by increasing the size of the tee to 20 feet by 20 feet, while it is now fitted with forty 15 watt pearl gasfilled lamps enclosed in clear well glass fittings. This alteration gives a much improved visibility both by day and by night.

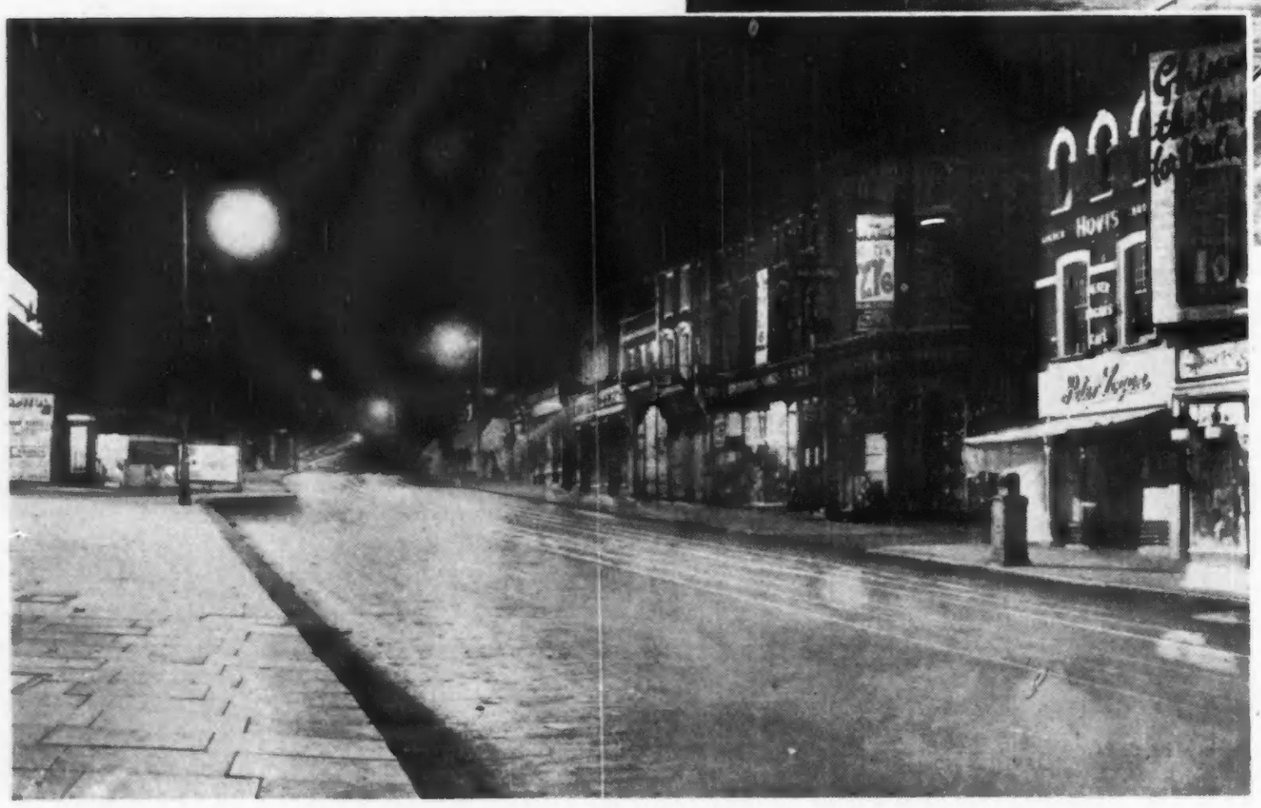


Fig. 57.—Osira street lighting at Lewisham.

Fig. 58.—Another Osira street lighting installation. View shows the main Oxford Road at Reading.

Wind Speed Indicator.

It is an advantage, though not a necessity for the pilot to know the approximate strength of the

wind so that he can gauge the correct point at which he should turn into wind to land. For this purpose, a wind strength indicator has been designed consisting of a small windmill driving a governor which operates mercury switches connected to an illuminated sign fixed flat on the ground and having two 6 ft. figures which may be changed in a manner similar to that employed for changing programme-number signs in a theatre. The wind strength is shown in steps of 5 miles per hour such as 0, 5, 10, 15, etc., while the windmill is kept facing into the wind by means of a tail fin, the inertia of the wheel preventing the indication from being affected by gusts. The use of tilting mercury switches in the control gear makes the change definite from one set of lamps to another and eliminates hunting.

ARTIFICIAL DAYLIGHT LIGHTING.

A number of further installations of artificial daylight have been put into operation during the year with results which demonstrate that not only is this form of lighting more reliable than any other type of artificial daylight for purposes of colour matching, but that actually, far more consistent matching is obtained with its use than is possible with natural daylight under the varying conditions due to locality and time of day. Until the advent of this form of lighting, there were many key industrial processes which could only be carried out during the daylight hours, a condition of affairs which proved a serious handicap when a factory wished to increase its output by overtime or extra shifts. To-day, with this form of artificial daylight available, it should be possible for any industry to function as well by night as by day.

Another interesting application of artificial daylight lighting is the installation in the main hall of the new R.I.B.A. Building, where a circle of artificial daylight tubing has been used in conjunction with ordinary artificial lighting to bring out the true colours of the painted ceiling in the dome.

CLEORA TUBING.

The production of Cleora tubing by Claude-General Neon Lights Ltd. (an associated enterprise of the G.E.C.) is of great moment. To appreciate the full significance of the new tubing it is necessary briefly to recapitulate the limitations of existing neon tubes.

The range of "natural" colours in neon is limited to three: (1) neon gas, giving a characteristic red, (2) neon gas, with the addition of metallic mercury, giving blue, and (3) helium, producing a white discharge. By the use of uranium glass, the blue tube discharge appears green, and the white discharge appears gold. Although there is a certain filter effect in the uranium glass, part of the inherent loss is regained by the fluorescence of this material. Other shades have been introduced, but depend entirely upon a filter glass, with a consequent rapid lowering of the efficiency of the light output of the tube.

Cleora tubes mark an entirely new departure, as their internal coating acts as a light wave-length converter. They are all based upon the blue discharge and provide at the present time a range of 16 colours that vary from red and brown through gold, yellows, greens and blues to lavender and heliotrope, and include white and off-whites. The extra scope that this addition to the colour range gives to the design of displays is most marked, and from this point of view alone this new development would rank as the most important since the introduction of the first neon tube. There are, however, further advantages in the practical use of Cleora tubes. A normal neon tube is completely translucent, and therefore cannot be used unilluminated as a decorative element, unless mounted on a suitable background. Cleora tubes are apparent solids, and backgrounds can often be dispensed with as the outlining of the design is clearly demarcated by the tubes themselves even when they are not illuminated. Further, a considerable saving in the complexity of electrical elements is made due to the fact that all these tubes, irrespective of their apparent colour, have identical electrical characteristics. In practice it is possible to erect a complicated multi-coloured design with far fewer transformers than would be needed were normal blue, red and helium tubes used.

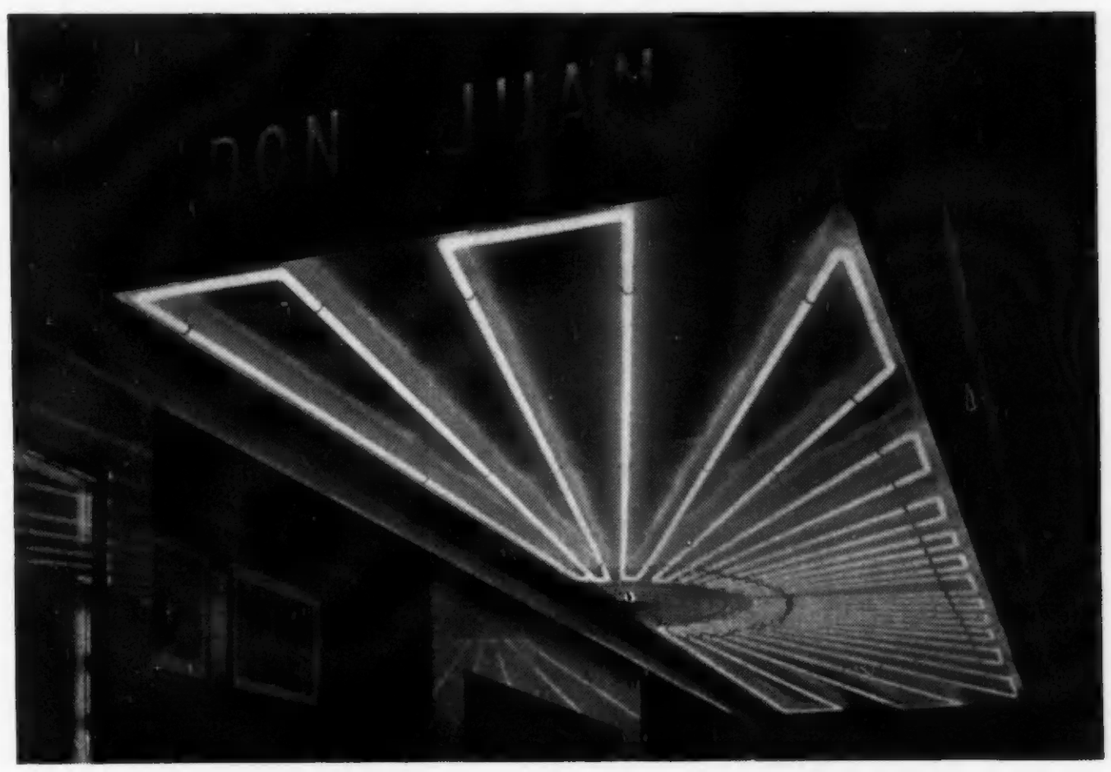


Fig. 59.—The canopy of London Pavilion, Coventry Street, illuminated on the under side by means of Sunlight and Cleora tubing.

The first practical use of the new tubes was made in the 1934 Ideal Home Exhibition at Olympia where the main *Daily Mail* sign over the East-end feature was carried out in an off-white effect. The architect responsible for this work was Ian Jeffcott.

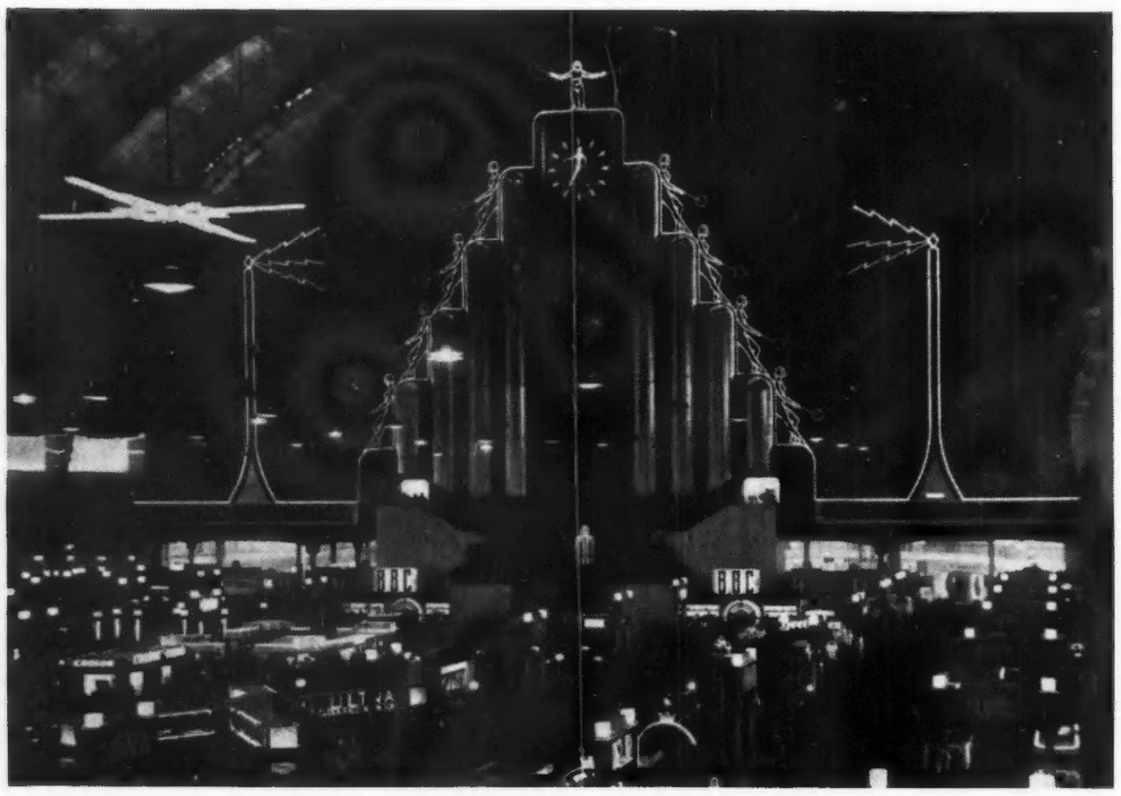


Fig. 60.—Radiolympia, 1934, showing the large flashing decorative neon lighting scheme which was synchronised with Big Ben.

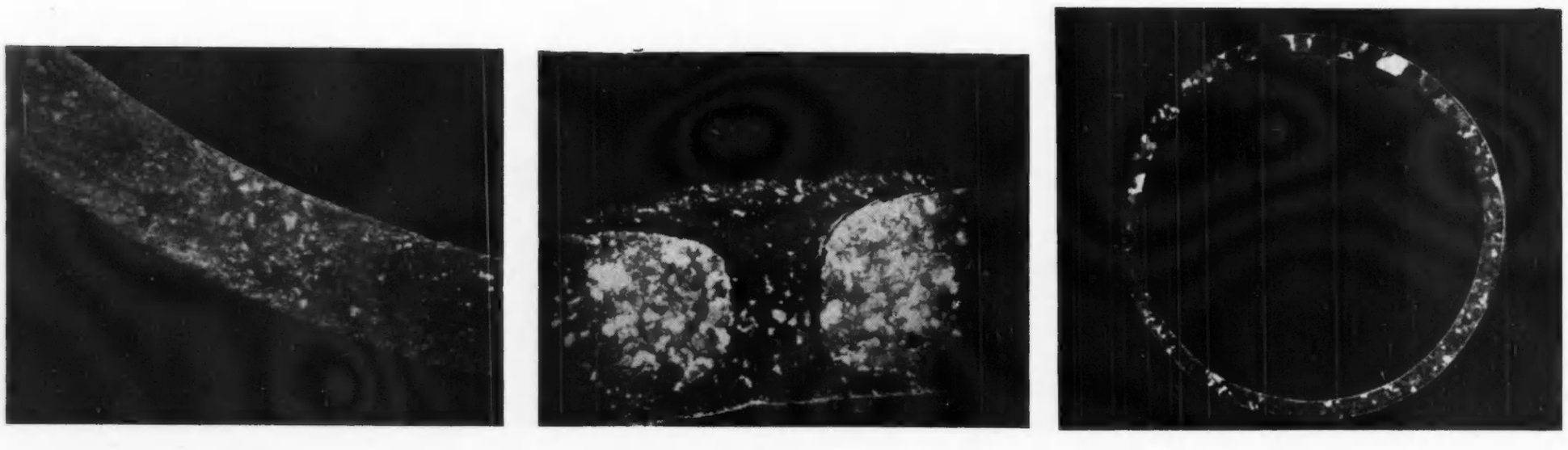
The first large external use of Cleora tubes was on the Dreamland Building at Margate which was designed by Leathart, Iles & Granger. Another building upon which it has been used with great effect is the London Pavilion. In this instance it is also used in combination with sunlight tubing on the main canopy (fig. 59). It is worthy of note that on the Coventry Street frontage, underneath the main canopy, readings of upwards of 20 foot-candles have been registered, without any incandescent illumination being used at all.

NEON LIGHTING.

A scheme of a most ambitious nature was employed at the Radio Exhibition held in September at Olympia. The main scheme of decoration, and in particular the west-end feature, fig. 60, was carried out in neon. This feature consisted of a series of neon figures reclining against the side of huge gongs and carrying neon mallets. Nearly 90 feet above ground level, a further neon figure, astride an electric clock, carried a similar mallet in each hand. The Marconiphone Co. Ltd. and the B.B.C. arranged for the clock and neon installation to be synchronised with Big Ben ; the Westminster chimes were relayed to link up with the beating of the gongs by the neon figures on either side ; while at the end of the chime period the topmost figure marked the beat of the hours. This is the first time that movement on such a comprehensive scale has been applied to a neon display at an exhibition.

In the field of interior lighting, the opening of the Blue Lagoon at Clacton showed how in certain circumstances neon fulfils a purpose that is not duplicated efficiently by any other means of producing light. Three lines of tubing—red, blue and green—are exposed on the ceiling of this dance hall and for the first time rotary dimmers have been efficiently used to provide a constantly changing cyloramic effect. The pastel shades obtained are most varied and attractive.

Neon has been used for the canopy of the Regal Picture House, Edmonton, in a form not previously seen. The canopy runs parallel to the ground for some half of its total width and then rises at a noticeable angle. Red and green tubes are placed at intervals down the depth of the underside of the canopy and follow its contour.



(a) (b) (c)

Fig. 61.—(a and b) sections of lead sheath extruded by vertical type lead press, showing longitudinal welds : (c) etched cross section of cable sheathing, extruded by new type lead press.

In dealing with smaller signs, a considerable advance has been made by the introduction of the "T" type sign which is in box form, self-contained and glass fronted. The glass is sign-painted entirely in an opaque colour, only the desired wording or design being left clear. Only the main wording or

design has a neon tube behind it, bent to follow its outline; a suitable reflector illuminates the subsidiary wording or designs by reflection. This development enables a sign incorporating a great deal of wording or very complex design to be neon-illuminated at a very low cost, and in many cases overcomes the difficulty and expense of bending tubes to the shapes of letters only a few inches in height.

NEW CABLE WORKS EQUIPMENT.

The efficient extrusion of lead sheathing is a most critical operation in the production of lead cables. Pirelli-General Cable Works, Ltd. has developed a new type of lead press which entirely obviates certain defects which are inherent in the design of the ordinary vertical type of lead press hitherto employed.

When using the vertical type of press the walls of the lead sheath are not built of a homogeneous material owing to the manner in which it is necessary to divide the plastic lead stream in order to extrude it in tubular form around the cable, also due to the fact that the container has to be filled up frequently with fresh lead. When the container is open to receive the fresh charge of lead, the surface rapidly oxidises so that the new and old charges of lead do not completely amalgamate, and as the lead moves forward through the press in the manner of a viscous fluid, its motion is comparatively rapid in the centre and slow at the confining walls. Thus the new charge of lead in the centre passes through the press more quickly than the old charge of lead, adjacent to the walls of the press. This results in longitudinal seams or welds being formed in the lead with thin oxide films between them. Fig. 61 which is from a photograph taken of sections of cable sheath, shows a number of these layers of lead.

The oxide films between different charges of lead are responsible for the familiar failure of lead sheaths in the form of longitudinal splitting when they have been subjected to internal pressure or bending.

To overcome these defects numerous ideas have been put forward many of them forming the subject matter of patent applications. They have not, however, proved practicable.

The new type of press is continuous in operation and no new charges of lead have to amalgamate with one another, so that oxide films are obviated. An etched sample of a lead ring cut from lead sheathing extruded by the new type press is shown at fig. 61. Any of the lead alloys used for pipes or cable sheaths can be extruded. As the press operates continuously, any length of cable may be sheathed without stopping the press. On test more than 35,000 yards of 32 m/m diameter sheathing have been extruded in one operation, also 1,000 yards of 102 m/m diameter three-core cable sheath.

The weight of the press is approximately $2\frac{1}{2}$ tons as compared with 70 tons for a vertical type press of approximately the same capacity. It is driven by an electric motor and may be heated either by electricity or gas.

Another machine, fig. 62, developed and installed during the year, is for the production of paper covering copper strips and wires. This is referred to in an earlier section of this article which dealt with transformers.

After careful consideration it was decided to instal a copper rolling mill, which will be housed in a steel-framed building together with a wire drawing and tinning plant. The rolling mill section will occupy an area of approximately 17,000 sq. ft. while the wire drawing and tinning plant will be contained in two 60 ft. bays, each 328 ft. long. A further intermediate bay will contain the offices and die setting rooms. Outside this building a large cooling plant has been constructed also settling tanks and an overhead crane capable of operating over an area of 19,000 sq. ft.

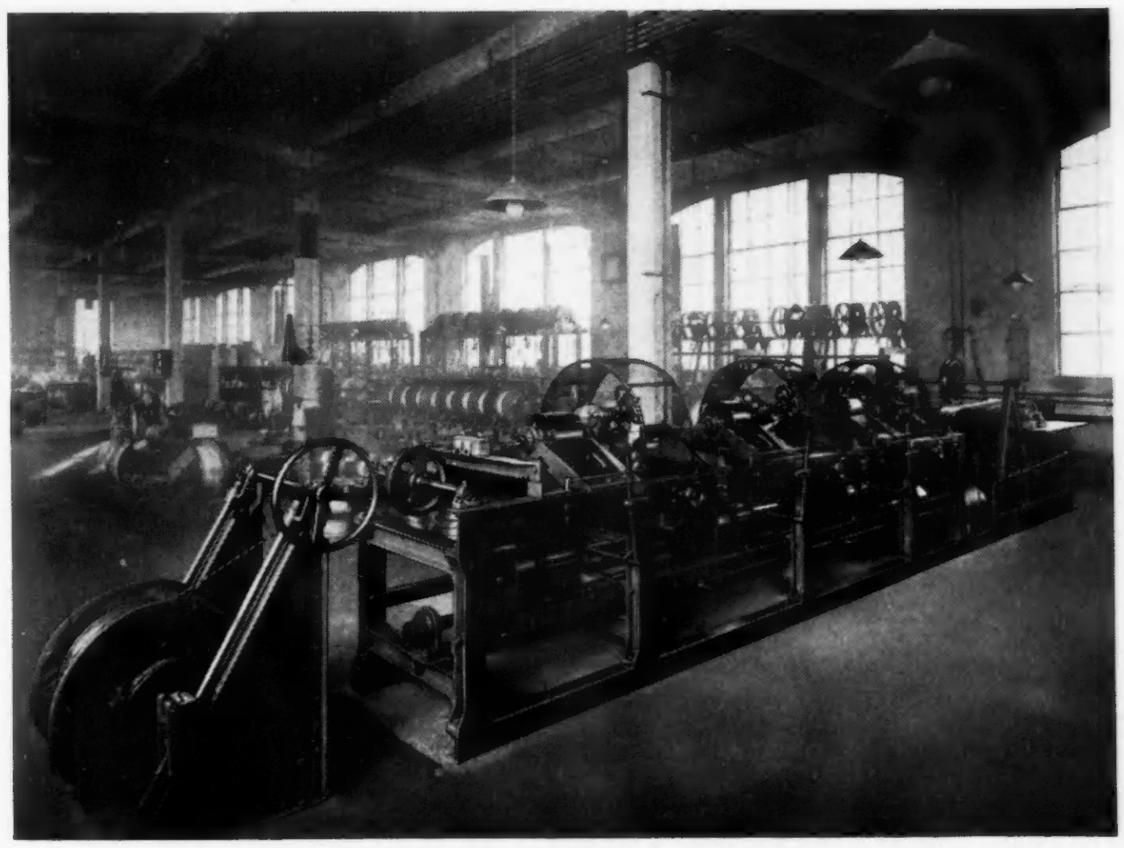


Fig. 62.—Machine for paper covering copper strips and wires.

The rolling mill is to be of the automatic type and all operations will be controlled from a main control bridge. When the plant has been completed the copper will be received at the works in the form of electrolytic wire bars. These will be fed into a large furnace at one end of the factory, withdrawn when correct temperature is obtained and fed into the various passes of the rolling mills and finally spooled as copper rod, all the processes being automatically controlled.

"VERTICABLE"

A new type of paper insulated lead sheathed cable is especially suitable for vertical installations where trouble in normal type cables may arise through migration of compound from the higher to the lower parts. This new type of cable has been termed "Verticable" and is insulated with paper, impregnated prior to application to the cable, with high melting point black waterproof compound having good insulating properties and high dielectric strength. It is much less hygroscopic than paper insulated cable and also than jute, because the narrow paper tapes are in much closer contact with one another than are the comparatively spongy fibres. The cable possesses the same current carrying capacity as ordinary paper insulated cable.

The methods to be employed for jointing are the same as for ordinary paper cables, but since the insulating material is waterproof, sealing ends in interior positions may be obviated if desired, the ends being taped up with high quality insulating tape.

As "Verticable" is a non-bleeding type cable it is particularly suitable for installation in vertical positions as in the case of lift cables, etc. With regard to dimensions, it is manufactured to standard

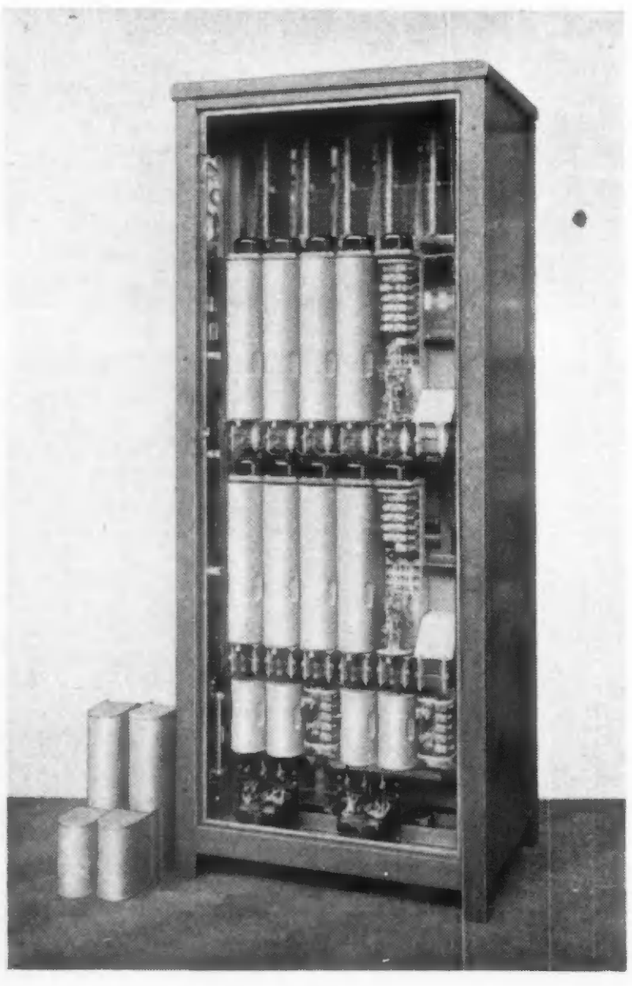


Fig. 63.—Rural automatic telephone exchange unit, specially designed for use in Australia.

specifications, and in multi-core cables the cores are distinguished by a coloured external layer of insulation.

RUBBER INSULATED CABLES.

A new type of cable named "Acmite" has been introduced. It is an outcome of the development of "Acmite" insulation, which consists of two layers of vulcanised rubber, the outer layer possessing properties which will withstand the effects of corrosion.

A flexible cord known as "Domestaflex" has been designed to provide a reliable means of connecting portable domestic appliances to the supply. Its outstanding quality is that it is non-kinkable.

INSULATING COMPOUNDS.

Considerable research work has been carried out on the properties of various compositions for insulating purposes, one result of which has been the evolution of an impregnated insulating tape having a dielectric strength comparable to Pirelli-General "Eeslee" tested tape which is strong and adhesive; but it possesses the additional property that if immersed in mineral oil, the compound will not wash out of the fabric, even at a temperature as high as 50°C. This tape, which is an entirely new departure in insulating tapes, has been named "Oylproof" tape and forms the subject matter of patent applications.

A further departure in insulating tapes has been effected by the introduction of coloured "Eeslee" tested tape, the colours available being red, blue, yellow and green. The tape is of the same quality in every respect as the black variety of this braided tape and is useful where high quality insulating tape is required in distinguishing colours for the distinction of phases.

TELEPHONY.

A notable development in telephone practice has been the introduction of the line finder system incorporating partial secondary trunking. This method of switching marks an important change in the principles of automatic telephony, and is the outcome of efforts directed towards effecting economy in switch quantities. The adoption of the line finder system affords an interesting example of the influence of development work on standard practice.

A further outstanding achievement is a new unit for use in rural automatic exchanges. Perhaps no communication problem has been the subject of such intensive research during the past few years as that of providing automatic telephone service in rural areas, a wide range of equipment having been produced. To this range is added the new unit, which is an advance on previous units of its type in that it may be linked to a number of neighbouring exchanges of the automatic, manual central battery or magneto types. These exchanges are allotted code digits, the dialling of any one

of which results in selection of a line to the particular exchange. Special features incorporated in the unit cause the calling condition appropriate to the type of exchange to be applied to this line. If the called exchange is automatic, the rural subscriber then dials the required number, connection being completed without the services of an operator. If a manual exchange has been called, the number is given verbally. This development thus results in a unit which, virtually universal, considerably improves rural service, since neighbouring exchanges of whatever type may be directly called through the rural automatic exchange.

The same idea of universal application underlies the development of special units for use in Australia, of which an example is seen in fig. 63. They incorporate an innovation whereby simple strapping of terminals permits the line circuits to be suited to the various types of subscribers' lines encountered, namely, loop; simplex-dialling, single and multi-party; single wire, single and multi-party; and coin-box lines.

Progress in automatic telephony has been accompanied by improvements in other branches of the public telephone service, and from the point of view of subscribers in Great Britain the most notable advances have been in connection with the trunk telephone service. Advanced design of switchboards and circuits, together with simplification of operating procedure and the provision of alternative routes has enabled the British Post Office to institute "on demand" trunk service throughout the major part of the country. This development so speeds up connections that only in abnormal times does appreciable delay occur when a trunk call is demanded. The country is divided into zones which are themselves divided into groups. A subscriber requiring a trunk call is connected through his local exchange to the exchange serving as a group centre. Here an operator extends the connection to the zone centre, from which access is gained to the trunk network. Special types of switchboards have been constructed, incorporating new features designed to assist the operator in the rapid handling of calls. The demand switchboard

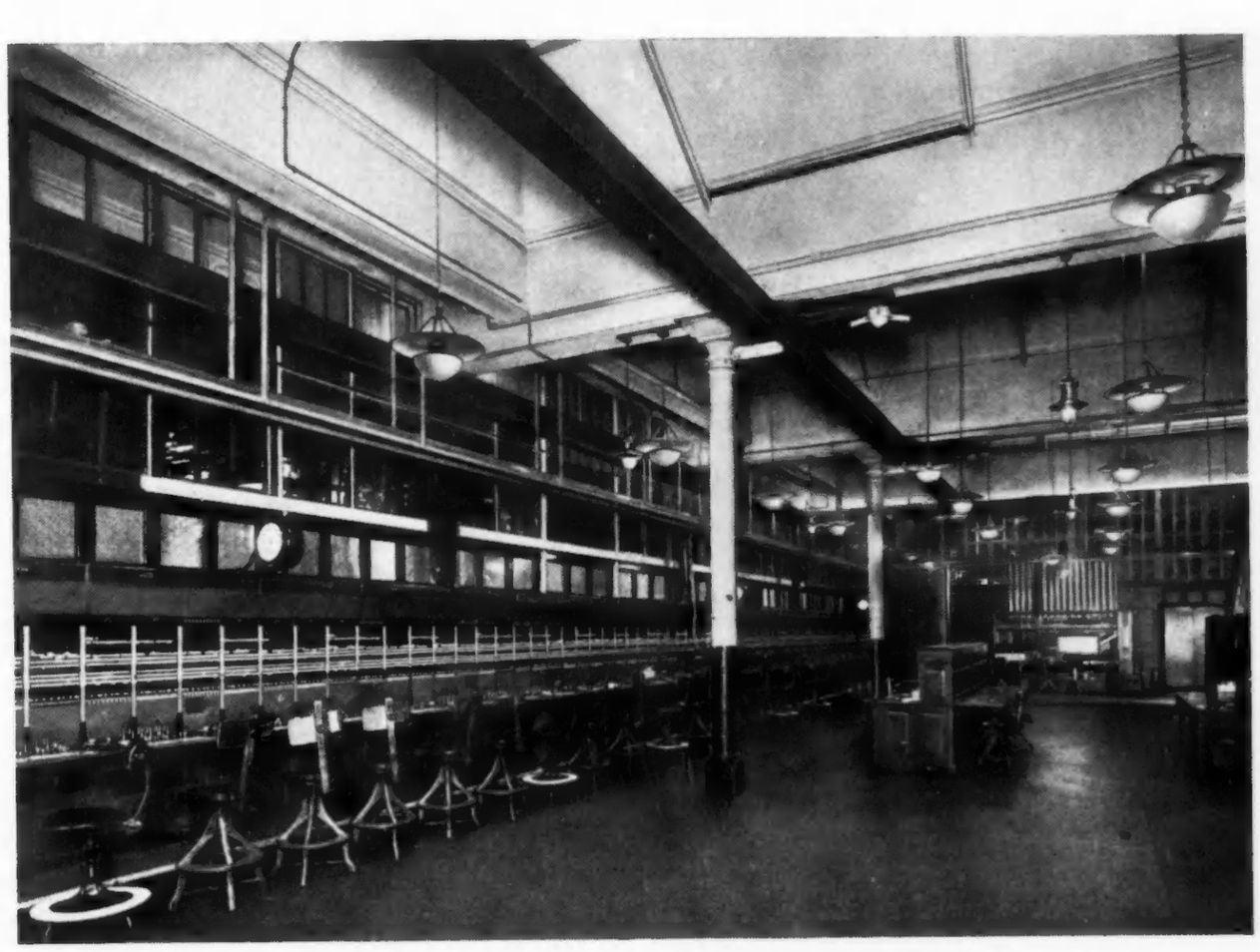


Fig. 64.—Demand switchboard at Liverpool zone trunk exchange.

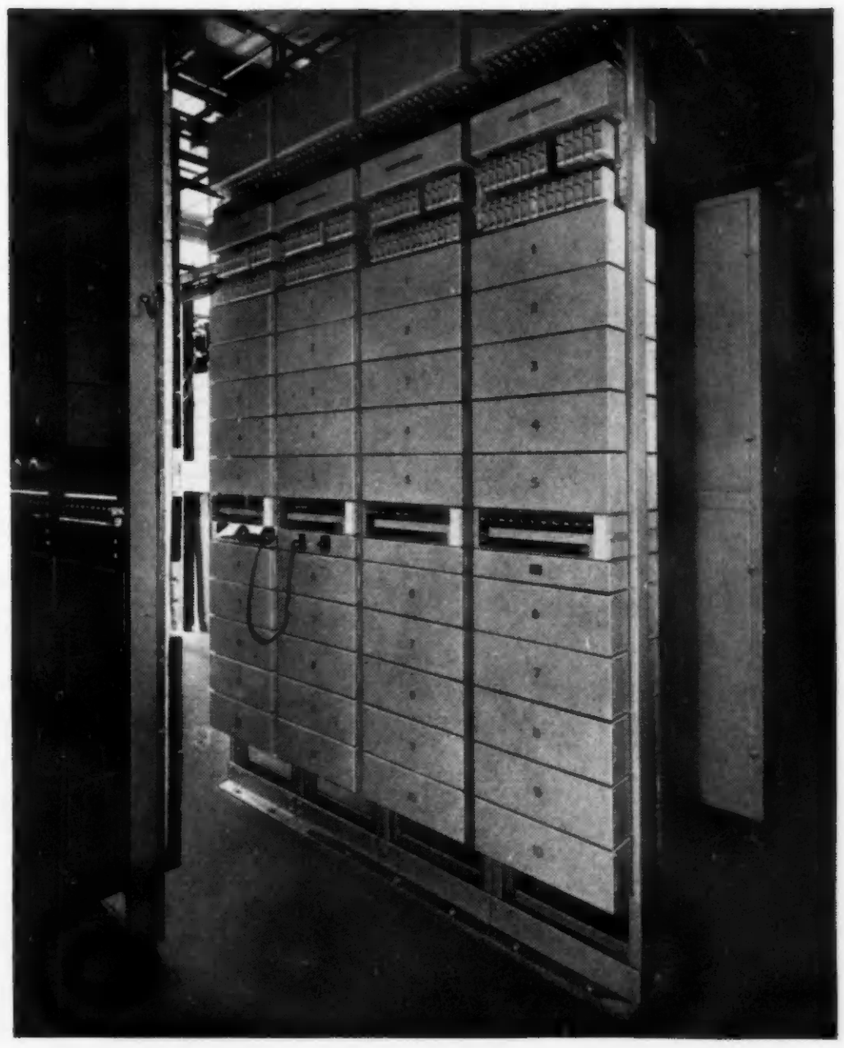


Fig. 65.—New double-sided repeater racks installed in Birmingham Repeater Station.

at the Liverpool zone trunk exchange is shown in fig. 64.

The growth in the trunk services has influenced the design of telephone repeater equipment, further progress having been made during the past twelve months. An entirely new range of repeater units has been designed, employing the new low consumption valves which show a saving in filament current of 80 per cent. The design of the unit presents a considerable saving in weight, whilst floor space economy is effected by mounting the units on each side of channel-iron racks, fig. 65. This

Fig. 66.—Mechanical key sender.

saving in current consumption, weight and floor space is of considerable importance in view of the tendency of repeater stations to become still larger. Considerable progress has also been made in facilitating maintenance. Repeater circuits are now connected to a test rack, concentrating testing of all circuits at one point, a development which, in view of the increase in the number of circuits, has obvious advantages. Also attributable to the increasing capacity of repeater stations is a development in regard to power plant. Instead of employing duplicate charging plant and duplicate batteries each capable of serving the station for two to three days, a single battery is now employed, current being supplied with the battery floating.

Reference was made in this Journal[10] to the research work in connection with the Gecophone subscribers' set which resulted in the attainment of a new standard of overall performance. Constructional details have been the subject of further attention during 1934, a modification in the design making the set still more suited to service under adverse climatic conditions. This modification relates to the cradle switch and is a development of the original design, giving almost complete immunity from troubles arising due to current leakage between contact springs in damp climates.

The widespread adoption of automatic exchanges for public service has had an effect on the operating procedure at private branch exchanges. When such an exchange is connected to an automatic exchange on the public system, the operator extends calls by dialling the required number, a great proportion of the operating time devoted to a call being spent in manipulating the dial. With the intention of replacing the dial and reducing very considerably the operator's time spent in originating impulses, the mechanical keysender illustrated in fig. 66 has been introduced. The sender is fitted with keys of the type-writer pattern, carrying the usual digit and letter designations of the dial. Impulses are originated merely by depressing these keys, the digits being stored by mechanical means as rapidly as the operator can depress the keys. Immediately the first key is depressed and released, impulses are sent out at the normal speed and continue until the complete train of impulses has been sent. The operator is free to attend to other calls as soon as the number has been set up by depression of the appropriate keys. As its name implies the keysender is entirely mechanical and the storage and sending of the impulses does not demand, as in the case of electrical keysenders, the use of relays, switches or current supply.

Of particular interest to the mining industry is the progress made during the year in the production of telephones and allied equipment with a still greater margin of safety. In the past, the flameproof qualities of mine telephones have provided the only safeguard against accidents but development of what is known as "intrinsically safe" apparatus places at the disposal of mining authorities equipment which has a primary protective quality in addition to being flameproof. In this direction much has been accomplished, the result of which will be to ensure in the future the greater safety of all mine workers.

The carrier current and supervisory equipment employed by the Grampian Electricity Supply Co., Ltd., formed the subject of an article in the last issue of this Journal.[11] No review of electrical progress for 1934 however, would be complete without brief reference to the importance of the scheme as it includes the use of carrier current channels for telephony and supervisory control over e.h.t. power lines in Great Britain for the first time, and is a tribute to the enterprise both of the Grampian Electricity Supply Co., Ltd., and Balfour Beatty & Co., Ltd., who were responsible for the design and layout of the extensive hydro-electric undertaking which operates over so vast an area in Central Scotland.

An increasing demand for carrier equipment for use on telephone lines has been accompanied by further research in this rapidly expanding branch

(10) G.E.C. Journal, Vol. V., No. 1, p. 37.

(11) G.E.C. Journal, Vol. V., No. 4, p. 234.

of communication engineering. Technical progress during the year has resulted in the design of equipment of which the keynote is simplicity, particularly in respect of maintenance. A notable application is that for the London & North Eastern Railway, designed to increase the number of communication channels over the aerial lines between Kings Cross and Glasgow. The trunk lines and the carrier sets are represented in fig. 67. Recent improvements enable a minimum of apparatus to be employed to provide a facility whereby, over the third channel of the three-channel systems, a private automatic telephone exchange at Newcastle is controlled by dialled impulses from an ordinary telephone at York, giving direct access from York to any Newcastle extension.

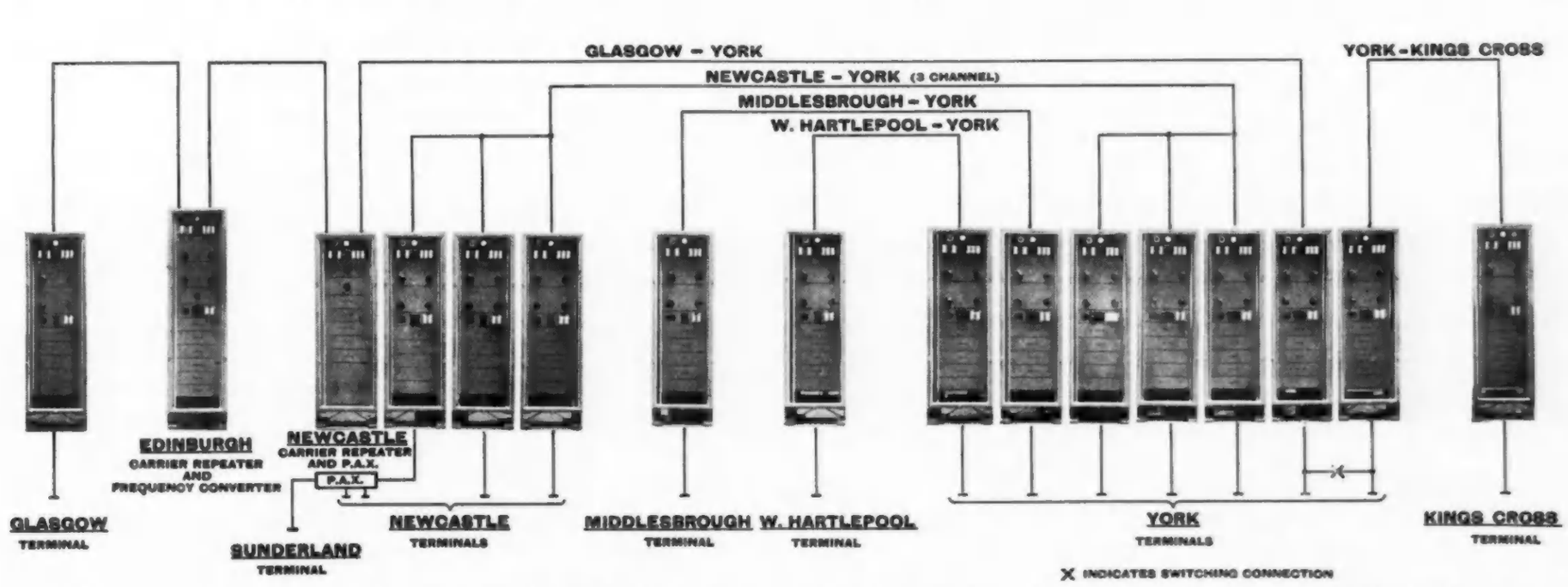


Fig. 67.—Diagrammatic representations of trunk lines and carrier sets installed on L. & N.E. Railway between Kings Cross and Glasgow.

Supervisory control of plant from a remote point has been the subject of several articles in this Journal. The rapid development of systems employing this principle has been a natural corollary to the growth in electric power distribution. To-day, remote supervisory control schemes can be adapted to control plant in a practically unlimited number of outlying substations linked in tandem by a minimum number of pilot wires. Further experimental work is directed towards ensuring the greater safety of personnel and apparatus. Remote control may be effected over pilot wires, which, when suspended from power line towers, may be subjected to high potentials as the result of the inductive effect of a current surge following upon a power line fault. On unprotected pilot wires, these high potentials may result in severe shock to operating staff and damage to the wires and apparatus. Protection of pilot wires continues to be the subject of research, the object being to obtain a device which will render ineffective the induced surges and be at once self-restoring in order to make the supervisory control circuits immediately available for indication of switch changes consequent upon the fault condition. A remote supervisory control installation to be completed in the near future will, by employing this latest development, incorporate high-tension protection of the pilot wires.

TRAFFIC CONTROL.

A new system of vehicle actuated traffic control developed by The Siemens and General Electric Railway Signal Co., Ltd., has met with complete success; it employs the usual light signals for traffic guidance and is marketed under the trade name of Autoflex. The unique type of road vehicle detector employed has attracted considerable attention.

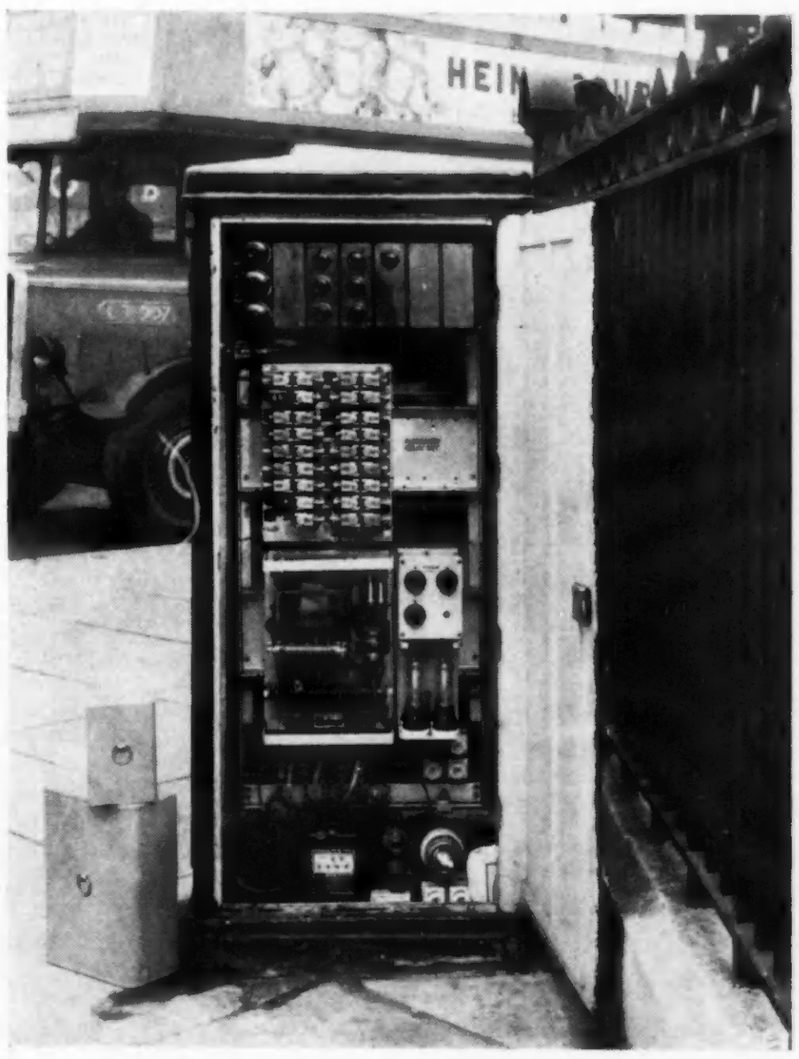


Fig. 68.—Autoflex traffic controller at a busy intersection of Kings Road, Chelsea.

The detecting equipment in the road consists of a rubber mat containing two air channels, the latter being connected to a pneumo-electric relay located under the pavement. Thus there is no electrical or contacting equipment in the roadway and the contacts can be inspected under actual service conditions without obstruction to the traffic or danger to the observer. The pneumo-electric relay includes two bellows, each of which is connected to one of the air channels in the road detector. Only the bellows associated with that side of the detector which is normally depressed first is fitted with an electrical contact, and the bellows are mounted in such a manner that they interlock.

Vehicles approaching the intersection inflate the contacting bellows for periods proportional to the times of occupancy of the detector and inversely proportional to the speeds. Impulses indicating the speeds of the vehicles are thus transmitted to the controller. Vehicles leaving the intersection and passing over the detector in the wrong direction inflate the interlocking bellows, which prevents operation of the contacting bellows so that no signal is transmitted.

The Autoflex controller is built up on the well known de-mountable unit principle which is used in modern automatic telephone exchanges. The whole of the switching is effected by means of

Fig. 69.—Decibel meter.

specially designed relays of the most modern telephone type. Neon impulse valves are incorporated in the timer circuits.

Apart from the relays, the equipment is purely static and comprises simple apparatus such as condensers and resistances. Owing to the absence of moving parts the equipment requires no oiling or other regular attention. In practice this is proving of great benefit and is resulting in a service which is remarkably free from interruption and trouble of any kind. Fig. 68, shows a 3-part cycle traffic controller in operation at a busy intersection in Kings Road, Chelsea.

MEASURING INSTRUMENTS.

Considerable progress has been made in the development of new measuring instruments, but it is possible in this article to give only brief particulars of the new types which have been introduced. It is proposed to deal fully with the whole subject in an early issue of this Journal.

New switchboard instruments include a range of $3\frac{1}{4}$ inch flush-pattern metal-cased instruments. They are fitted with moving coil, moving iron and rectifier movements. A range of thermal instruments, made in $2\frac{1}{2}$ inch insulated cases is suitable for radio-frequencies. These instruments are of the thermo-couple type with the thermo-couple insulated from the heater.

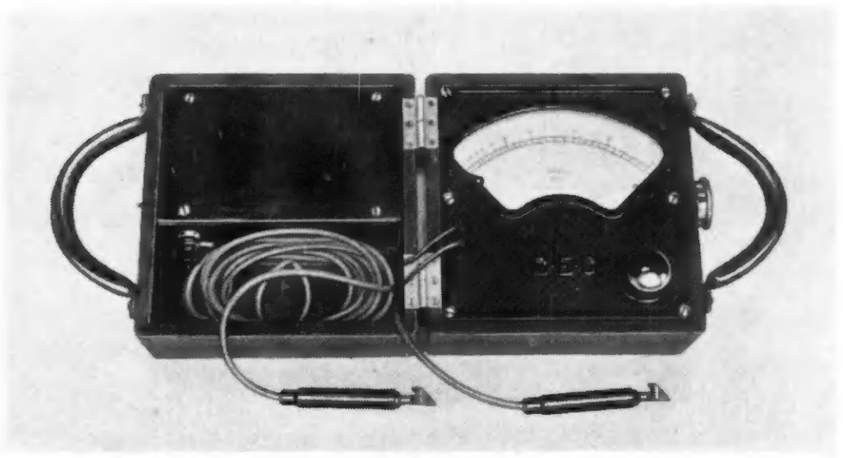


Fig. 70.—Earth continuity testing set.

A differential millivoltmeter has been devised for facilitating the rapid adjustment and checking of shunts and other low resistances, without the use of auxiliary apparatus. It may be used by unskilled or semi-skilled operators engaged on production.

A line of dynamometer wattmeters has been produced. The switchboard models are mounted in 8-inch cast iron cases for projecting or flush mounting, and the portable types are contained in polished wood cases. The movement is of the air-core dynamometer type with air damping and iron shielding. The single-phase and polyphase balanced load instruments are of the single-element pattern, and for the switchboard type a double-element wattmeter is supplied in the case of polyphase unbalanced load. The accuracy is substantially the same over the power frequency range although the instruments are normally calibrated at 50 cycles per sec. They may also be used or checked on direct current if required.

An ammeter, calibrated in pence per hour, which can be a small and inexpensive $2\frac{1}{2}$ or $3\frac{1}{4}$ inch instrument, is most useful for showing both the running cost of any individual item such as a cooker, kettle, iron, etc., and also for indicating whether the consumption is higher than anticipated.

DECIBEL METER.

Rectifier instruments are finding many applications in telephony owing to their wide frequency

range which adequately covers the audio scale. Under given conditions of load a rectifier milliammeter or voltmeter can be calibrated to read in decibels showing a power level above or below a given fixed level. To cover a wide decibel range adequately it is desirable to have a nearly linear scale and as the decibel is a logarithmic unit it is necessary for the original current or voltage scale to be made inversely logarithmic in order to counteract this. In the past instruments have been so made by shaping the poles or the core of a moving coil instrument, but in the Salford Decibel meter, fig. 69, this is achieved by means of a rectifier shunt to the movement. By suitably choosing the part of the

Fig. 71.—Variable frequency oscillator giving constant output having a sinusoidal wave form.

characteristic used it is possible to obtain a scale of current (or volts) which is very nearly logarithmic, leading to a nearly linear decibel scale.

As the current or voltage scale of the decibel meter is logarithmic it is possible to produce an a.c. voltmeter (or milliammeter) having a substantially logarithmic scale. This has some applications, particularly to circuits where the range of voltage to be indicated is very wide. One hundred ohms per volt at full scale deflection is the usual resistance, but for other rectifier voltmeters it is 1,000 ohms.

EARTH CONTINUITY TEST SET.

A new self-contained test set (fig. 70) has been introduced for the measurement of the resistance of earth connections, both copper conductors and steel conduit and armouring. For industrial and mining installations the actual resistance is of importance and this instrument is designed to have great sensitivity in that it will show small variations of resistance; also it passes an appreciable current through the conductor instead of the few milliamperes common with smaller test sets.

The test set has most scope in industrial and mining work where readings are made periodically so that increases of resistance at joints, etc., are detected before a high resistance occurs. The set, however, is also applicable to domestic installations, and it is of particular value at the present time in view of the new Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers during the year.

ALL-METAL LABORATORY APPARATUS.

A wide range of apparatus has been designed which comes within the category of all-metal laboratory apparatus; it includes oscillators, bridges, standard inductances, amplifier detectors, valve voltmeters, attenuation measuring sets, etc. The units are contained in tinned steel cases finished ripple black, a smooth surface not likely to hold dust. This construction provides electrostatic screening and electromagnetic shielding which is very desirable so as to avoid interference with the circuits from outside stray fields and *vice versa*. Most of the types of apparatus are made for operation from a.c. mains, but where such supply is not available other sources are provided for. Another advantage of the metal case is the better heat dissipation from components such as resistances, transformers and valves. Some examples of this range are described briefly below.

The beat frequency oscillator is a valve oscillator having a frequency range of 50 to 12,000 cycles per second, supplied either for a.c. mains operation or for batteries. The output varies from 0.5 to 1 watt, and is sufficient for much general laboratory work.

Fig. 72.—Illumination meter.

The variable frequency oscillator, fig. 71, is a high-grade instrument employing Gecalloy toroidal coils and is supplied for various frequencies which cover audio-carrier and radio work. The output is constant and of sinusoidal wave form.

For some purposes a fixed frequency oscillator is sufficient. This instrument is supplied with one, two or three fixed frequencies and is of general application to a.c. bridge measurements and other purposes.

The direct reading attenuation measuring set includes an indicating instrument of the self-contained reflecting instrument pattern which is directly calibrated in decibels. It is somewhat similar to the decibel meter (described above) but is more elaborate and includes a valve amplifier and

a valve rectifier shunt. It is suitable for a frequency range of from 30 to 8,000 cycles per second, and is calibrated at 1,000 cycles over a range from 0 to minus 30 decibels.

For radio frequency bridges telephones are useless as detectors, owing to their frequency range being limited. The aural heterodyne detector has therefore been introduced. It comprises a heterodyne detector and amplifier so that telephones may

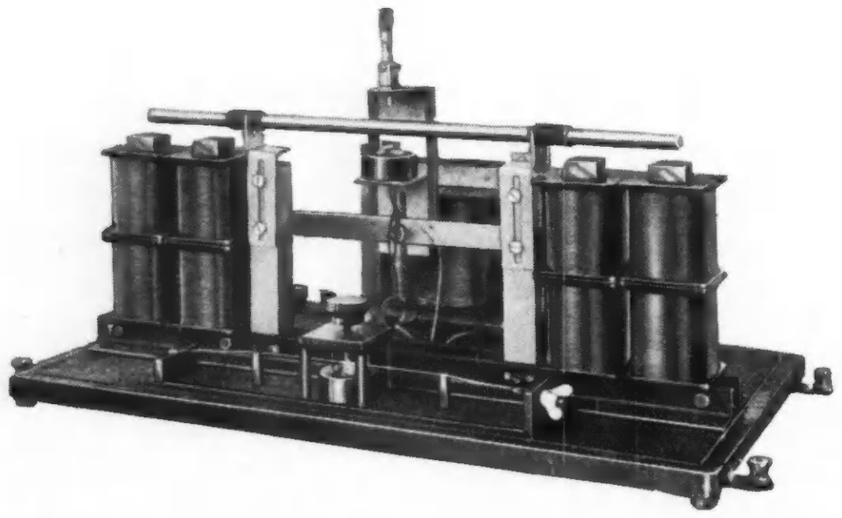


Fig. 73.—Electro-magnetic fatigue tester for giving life test on sample metal bars.

be used at a convenient heterodyne frequency. The amplification increases the sensitivity of the resulting bridge measurements. Reference should also be made to a visual amplifier detector. It consists of a valve amplifier with a metal rectifier instrument.

PHOTOELECTRIC COLORIMETER.

An apparatus developed for the direct comparison of the opacity of liquids by means of photoelectric cells, has been named the photoelectric colorimeter.

Fig. 74.—Chamberlain & Hookham time meter.

The apparatus comprises a lamp and two similar glass cells for holding the liquids. The opacity, and so the concentration, etc., of a solution can be determined in terms of a known standard solution, the output from the two photoelectric cells being balanced and the difference shown on the calibrated galvanometer.

This instrument is of use for many purposes in analytical chemistry. As little as 0.2 cc. of liquid can be used and the instrument only requires connection to the mains (d.c. or a.c.). The sensitivity is higher than can be obtained by visual means.

ILLUMINATION METER.

The Salford illumination meter has been produced for the direct measurement of illumination in foot-candles. It consists of a photoelectric cell of the self-generating "rectifier" type described at a later stage of this article. The cell is connected to a low resistance galvanometer, and the combined assembly has a sensibly linear response to the incident light. The scale of the instrument is practically uniformly divided and the full scale deflection is 50 foot-candles. It can also be supplied with a full scale deflection of 250 foot-candles.

The cell is mounted in the lid of the instrument, so that it is protected from mechanical damage and also from temporary fatigue and reduced sensitivity, which can occur due to prolonged exposure to light.

This foot-candle meter is designed primarily for measuring illumination in interiors, and probably has its chief application in industry where it is essential to maintain certain levels of illumination in order to carry out specialised operations efficiently.

COMPARATIVE PHOTOMETER.

The "comparative" photometer is designed to enable the light output and wattage of lamps of the same rating to be compared, and is suitable for

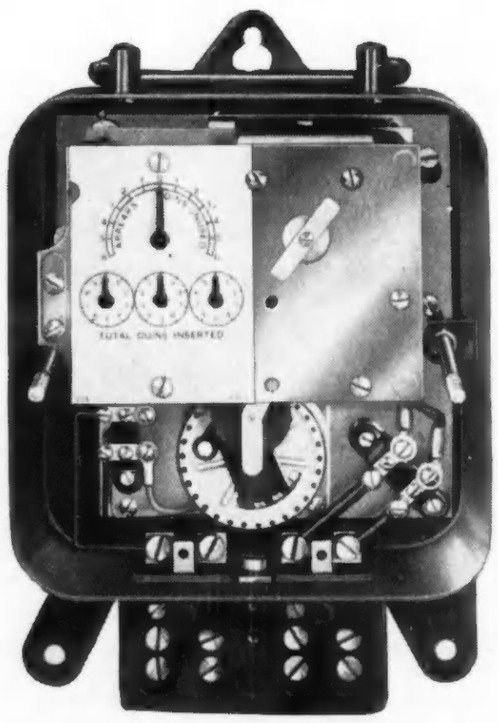


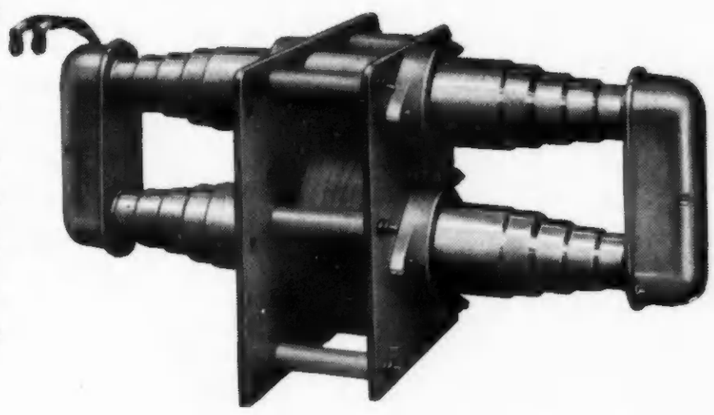
Fig. 75.—Internal view of rental meter.

testing general lighting service lamps of voltages between 100 and 130 or 200 and 260 and wattage ratings from 15 to 100 watts. With this photometer the greater light output of lamps manufactured by modern controlled methods can be compared with that of poor quality lamps of the same voltage and wattage rating.

THE FATIGUE TESTER.

An apparatus known as the Fatigue Tester, which was originally devised in the G.E.C. Research Laboratories, has been developed in practical all-mains form at Salford Works. Provision is made for performing a life test on sample steel bars, but non-magnetic metals may be adapted for the test also. The sample bar or rod is supported at two nodes and is vibrated electromagnetically. In this way a very great number of cycles of stress can be applied to the bar in a relatively short time; further, if the modulus of elasticity, E, be known; by measuring the deflection of the bar at an antinode the actual stress applied can be calculated. To indicate the number of cycles applied to the test bar before failure occurs a recorder is used. Finally, a means of tripping the whole gear is provided to operate on the occurrence of a crack in the specimen.

More than one bar may be vibrated at once by providing several electromagnets and by varying the stress on each, different failure times occur which can all be indicated on the one chart of the recorder.



ELECTRICITY METERS.

The tendency in the direction of all-insulated apparatus, noted earlier in this article, is well illustrated by the fact that the Chamberlain & Hookham type "H" single phase meter—described in a previous issue of this Journal[12]—is now obtainable in a bakelite case.

In the past, it has been necessary or desirable to earth the case of the meter when fixed on a consumer's premises in order to eliminate the risk of

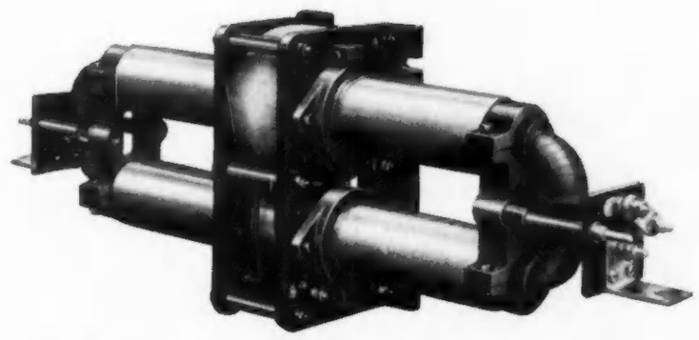


Fig. 76.—22 kV current transformer.

shock should the case become "live." This rule has been more honoured in the breach than in the observance. The modern tendency is to put in an all-insulated service comprising a dividing box, main switch and fuses, and meter, thus doing away with the necessity for earthing.

The bakelite case has been designed so that screw threads in the bakelite are avoided. The series terminals are removable and all metal parts of the case are inserted or attached after moulding.

(12) G.E.C. Journal, Vol. IV., No. 1, p. 42.

A wide joint between the cover and the back of the case together with a cotton wick gasket in the cover ensure a dust tight joint. The method of attachment of the cover to the case also ensures

Fig. 77 (*below*).—**66 kV current transformer removed from tank.**

Fig. 78 (*right*).—**View of 66 kV current transformer enclosed in oil-filled tank.**

that no stresses are set up tending to fracture or distort the bakelite.

A time meter shown at fig. 74, consists of a small synchronous motor driving through a train of wheels to a cyclometer counter registering in hours. It is supplied in a pressed steel case for any standard voltage and for a frequency of 50 cycles. In a works where motors, welding machines, or other apparatus which are used intermittently are employed, this meter enables a record to be kept of the hours during which the machine to which it is connected has been working.

A new rental meter, seen at fig. 75 consists of a mechanism similar to that used in prepayment meters but coupled to a small synchronous motor instead of a meter. The object of this device is to provide a consumer with a supply of current at a fixed rate per week independent of the amount of current consumed. It is useful in collecting charges due on the hire or hire-purchase of apparatus such as cookers, radiators, kettles, etc., or for collecting the standing charge on a consumer's installation. In the latter instance, a second prepayment meter may be connected in series for collecting charges for current consumed.

When a shilling is inserted and the handle turned, a switch is closed in the consumer's main circuit. The pointer moves from zero to 1 on the "coins unused" scale and the motor proceeds to drive the pointer back towards zero. Assuming that the mechanism is geared for one shilling per week, the

pointer will reach zero in one week's time and the switch will open. The consumer can obtain no more current until a further coin is inserted and if he neglects to insert a coin the pointer travels into the arrears portion registering at the rate of one shilling per week. Before the supply can be resumed, the consumer must insert a sufficient number of coins to cancel the arrears, after which the switch will again close on the insertion of a coin. In a modified form of this device, provision is made whereby the consumer may obtain a supply for a limited period on inserting one coin notwithstanding the fact that he may be in arrears. This is a convenience to the consumer who may have only one coin available at the time when a supply is required.

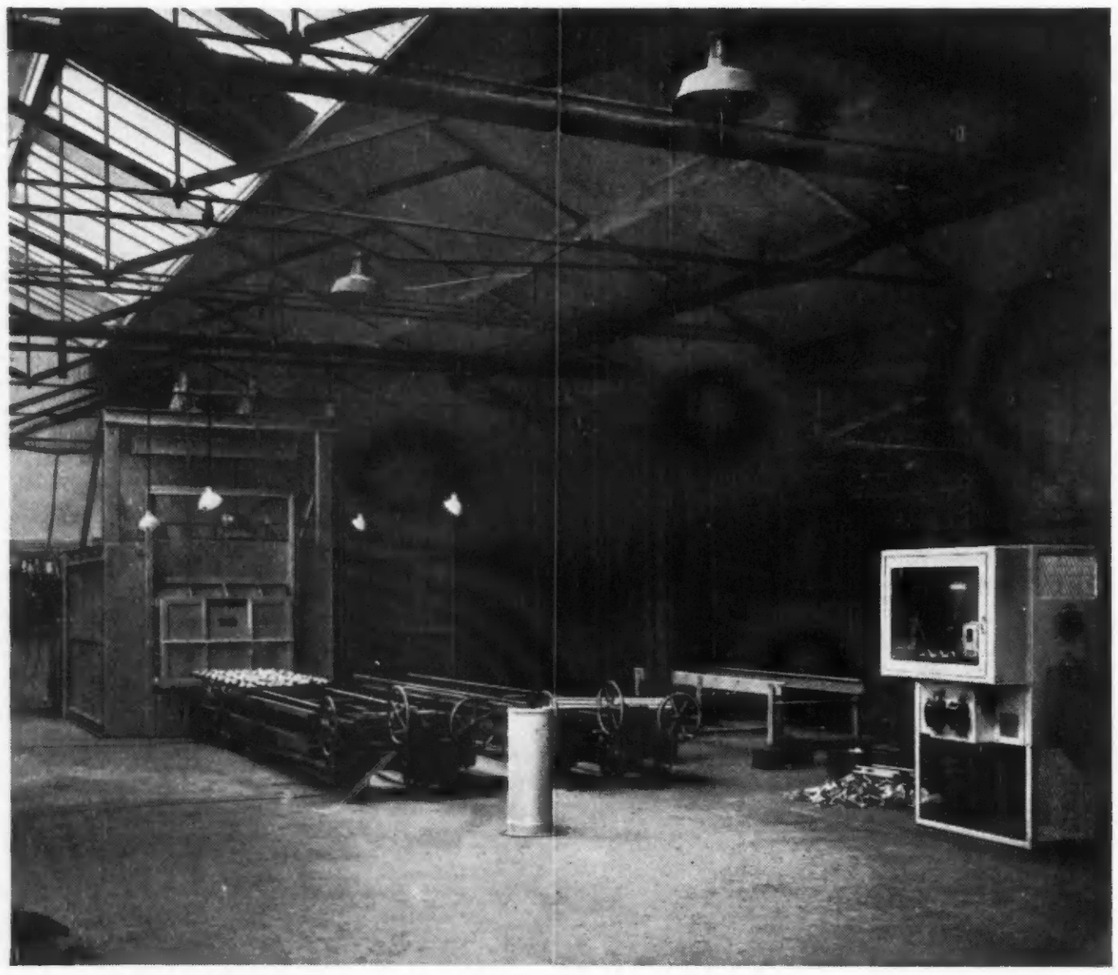


Fig. 79.—200 kW vitreous enamelling furnace, with automatic temperature control gear and motor-driven door operated by push button.

A current transformer for a working voltage of 66 kV, figs. 77 and 78, has recently been developed. The transformer, which is of the wound primary type, has two tubular condenser bushings mounted in a metal chassis. The primary is wound through the tubular bushings and the ends of the winding are protected by the rounded aluminium casings attached to the ends of the bushings. These rounded casings which are at the same potential as the primary also prevent any discharge from taking place between the high tension conductors and adjacent metal work. The core and secondary winding are mounted on the lower condenser bushing between the two plates of the chassis.

Another new current transformer for a working voltage of 22 kV is shown in fig. 76. This also consists of two condenser bushings mounted in a metal chassis with the core and secondary winding on the upper limb. The primary is wound in two sections, which may be connected in series or in parallel giving two different ratios of transformation. The ratio may be changed by means of link connections fixed on bakelite terminal blocks at both ends of the transformer. The complete transformer is intended for use in air.

ELECTRIC FURNACES.

The development of the G.E.C. patented[13] controlled atmosphere process for bright annealing has been extended, and satisfactory results have been obtained in connection with the bright annealing of phosphor bronze. The bell type of furnace may be used for annealing, normalising and heat treating metals in an artificial gas atmosphere. The heating and cooling cycle and the atmosphere surrounding the charge may be completely and precisely controlled.

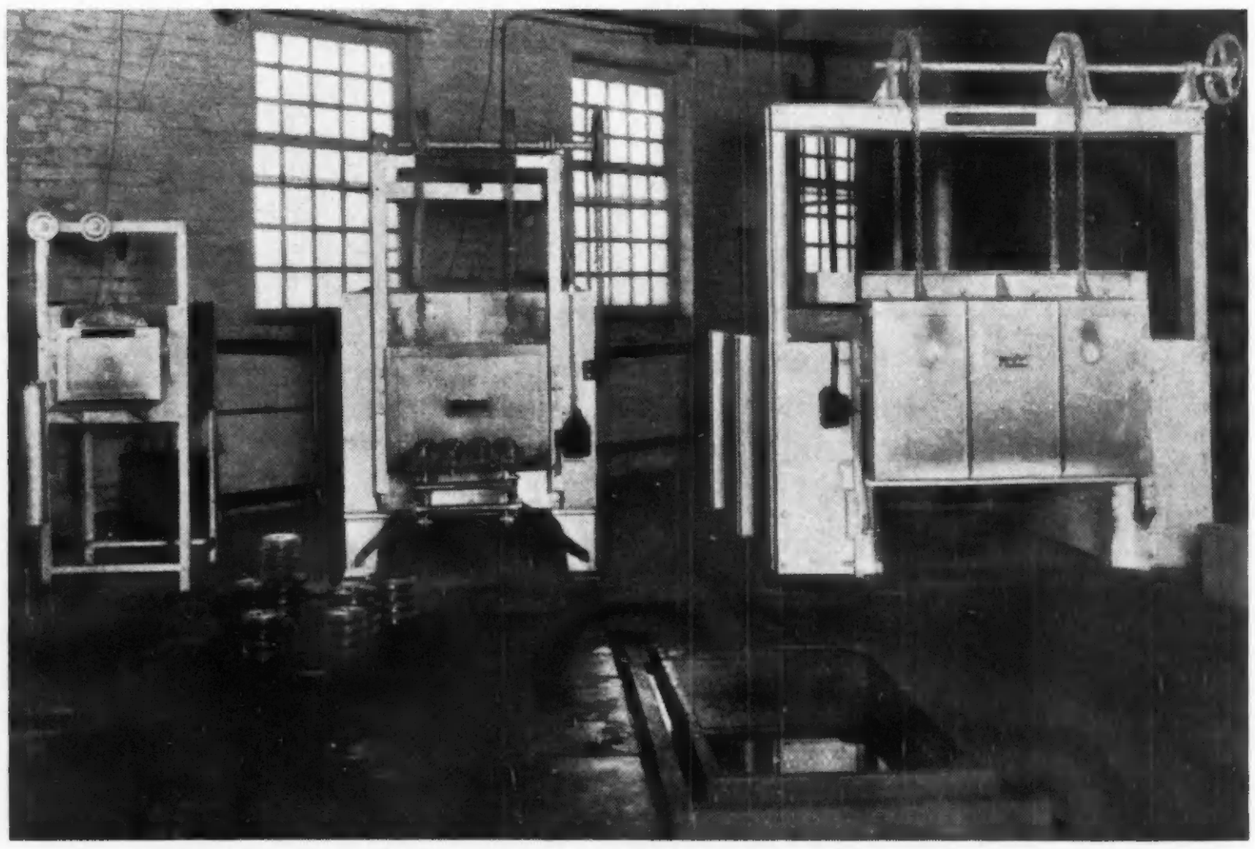


Fig. 80.—Installation of furnaces in the Johnstone Works of John Lang & Sons, Ltd.

Installations of furnaces embodying the principles of the Grunewald process bear testimony to various advances which have been made. Two of these installations comprising three furnaces and twenty-four Grunewald pots are for the bright annealing of

(13) Patent No. 415,428.

cold rolled strip. Other installations are for the bright annealing of copper and phosphor bronze.

Furnaces representative of all the principal commercial types have been built. Individual reference should be made to nitriding furnaces exported to Australia.

A range of forced air furnaces has been designed for the rapid and uniform heating of charges of small parts to moderate temperatures. Extremely close control is obtained automatically under the normal conditions of production. An improved form of automatic temperature control gear cubicle has been introduced, while considerable progress has been made in the development of excess temperature fuses for furnaces operating at temperatures ranging from 1080 to 1400 degrees Centigrade.

A licence for the manufacture of arc type steel melting furnaces has been obtained from Brown, Boveri & Co., Ltd., whereby advantage may be taken of their designs and patents. These furnaces can be manufactured with capacities ranging from 6 cwts. to 20 tons. Sole rights have also been acquired from this firm for the manufacture of electric cremation furnaces.

ELECTRODE BOILERS AND CIRCULATORS.

Several electrode circulators and steam generators have been installed, typical of which are two 750 kW, 6,600 volt circulators required to heat by the thermal storage system the buildings of a technical college. The equipment is completely automatic in action, being controlled by a thermostat working in conjunction with a time switch which ensures that heating is only carried out during off-peak periods.

WATER HEATERS.

Open outlet water heaters hitherto have suffered from the disadvantage that, in order to prevent wastage of water as the contents expand under increasing temperature, a siphon-cap has been fitted at the top of the stand-pipe. This fixes the minimum quantity of water which can be withdrawn at one time. An automatic vent valve is now, therefore, fitted to the smaller sizes of non-pressure water heaters. This gives the advantage that small quantities of water can be drawn from the open outlet type of water heater exactly as in the case of the pressure type.

BAKING OVENS.

The use of additional steam in baking ovens is becoming very general, chiefly because of the increased demand for Viennese and other fancy breads. The general practice hitherto has been for this steam to be supplied from a boiler of very small steam capacity situated in the bakery. Loadings of, say, 4 kW have been employed, steam being generated and stored at a pressure up to approximately 15 lbs. per square inch. On account, however, of the small capacity of the boiler the admission of steam to the oven would cause the pressure to drop so that the oven would always be moist and at a pressure not appreciably above atmospheric. When ovens are installed in bakeries where a main high pressure boiler supplying steam to the building for other purposes is available, it is obviously more economical to utilise steam from this boiler for the baking oven. In order to enable this to be done with safety a steam trap is necessary, which ensures that steam at the main boiler pressure is not fed directly into the ovens. This is important as not only is high pressure dry steam undesirable from the baking point of view, but furthermore, particu-

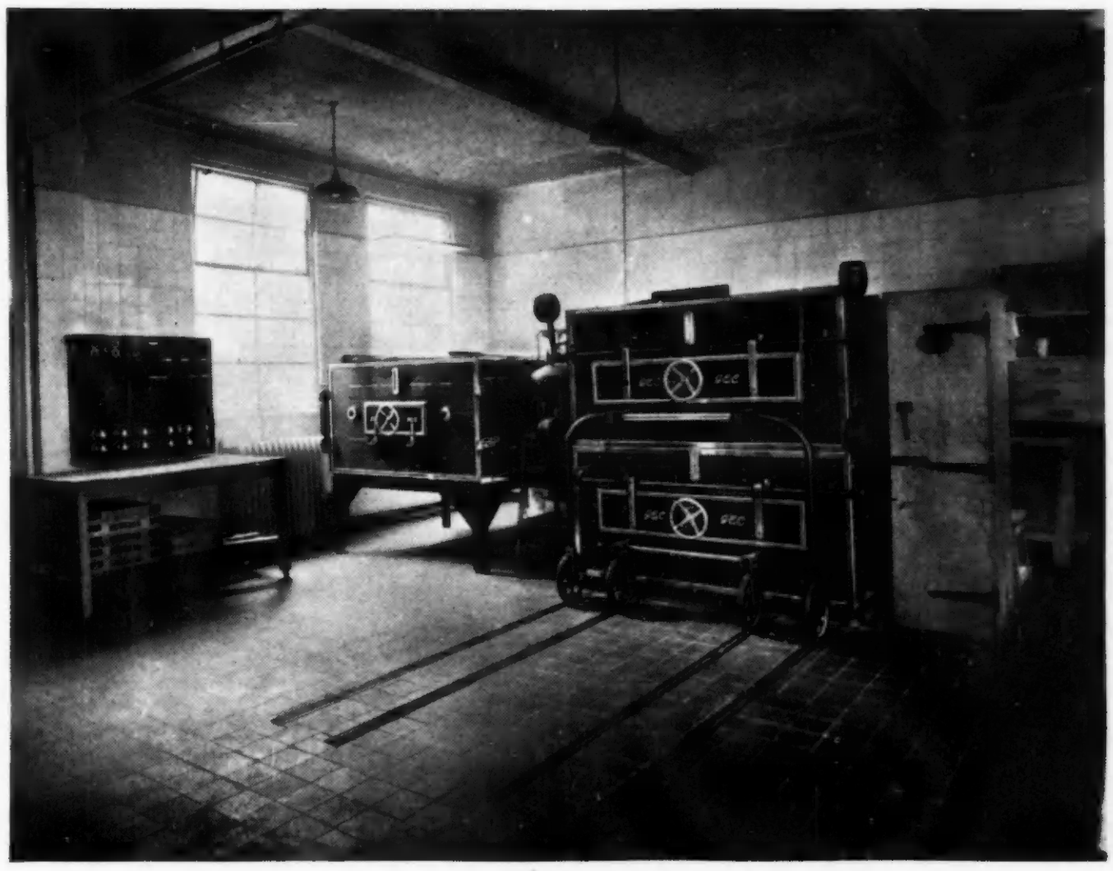


Fig. 81.—Electric draw-out type baking oven, installed in Stannard's Bakery, Norwich.

larly in the case of a metal built electrically heated oven which is virtually steamtight, a pressure might be generated in the oven itself, resulting possibly in damage to the oven or even in an accident.

STEAMING OVENS.

A new industrial electric steaming oven has been introduced which has the advantage of working

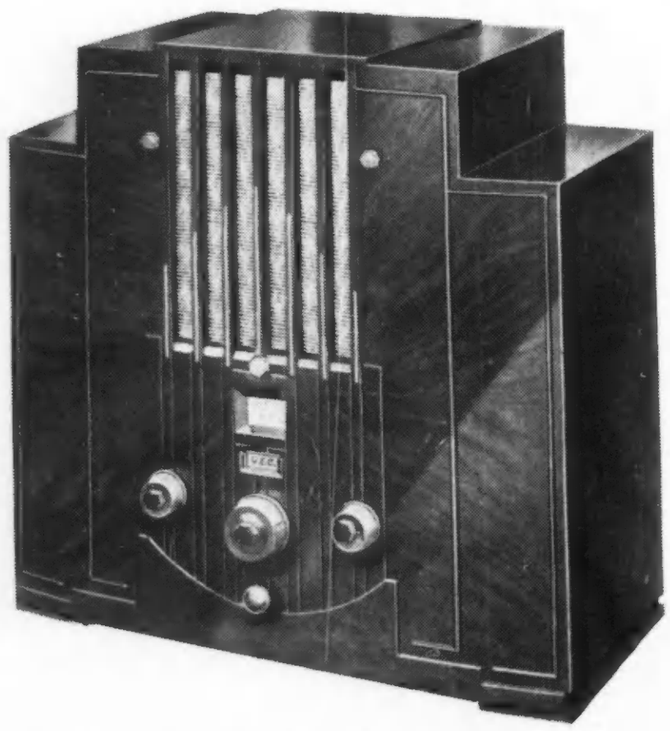


Fig. 82.—AC/DC 3-valve radio receiver.

at a slight pressure, whereas the former pattern worked at atmospheric pressure. Consequently, the new oven is much faster in operation, in recuperation, and also in the time occupied in heating up. Whereas the previous oven took 35 minutes to get up steam and 40/45 minutes to steam the full oven, the new oven takes 20 and 25 minutes respectively. The water well control switches and heating equipment are all embodied in the frame of the steamer making the unit compact. The water well, which has a ball feed, is fitted with a non return device and is heated by the same type of Magnet embedded immersion heater which is used in storage water heaters with three heat switch controls.

INDUSTRIAL ELECTRIC COOKING APPLIANCES.

Several new patterns of industrial cooking apparatus are being manufactured to meet the varied demands which arise. For instance a new pastry oven has been developed on simplified lines to meet the demand for confectionery baking on a small scale. In view of the success achieved by marine pattern embedded hotplates, restaurant type ranges have been reconstructed so as to accommodate this type of plate. The range of vegetable boilers has been re-designed and separate heating by means of a circular embedded hotplate is provided. The boiler or water container is supplied with two colanders for the vegetables. The container is recessed and sits directly on a solid hotplate in place of the hotplate formerly employed which was heated by means of clamp type elements. This method of heating is also employed for a new stock pot. The container for this appliance is made of heavy gauge aluminium which renders it very much lighter than a pot made of copper. Further, it is more easily cleaned and does not require retinning.

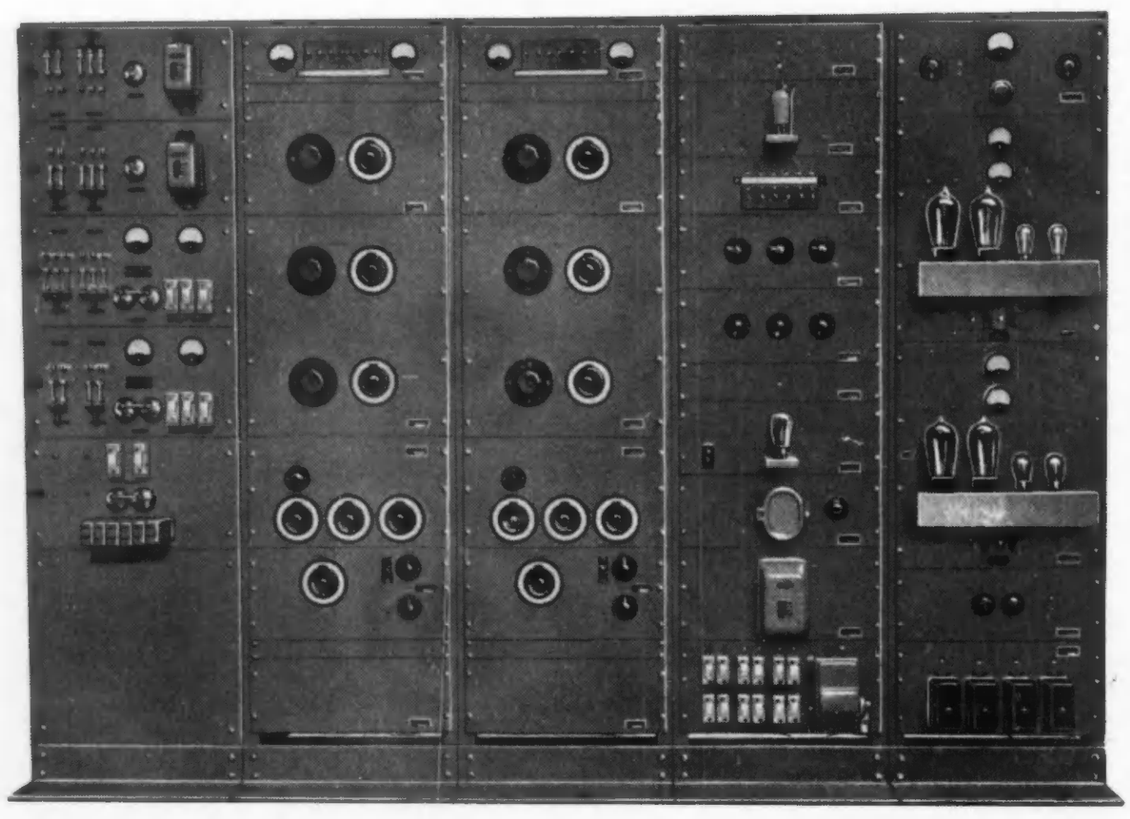


Fig. 83.—Typical colonial radio relay station, comprising duplicate short wave receivers, amplifiers and control panels.

RADIO SETS.

The past year has witnessed many improvements in the detail design of receiving sets, both electrically and mechanically, also the application of advanced technique to the simpler sets. For example, an advanced form of automatic volume control has been used in the five valve set and this maintains the output from the set at a steady level, in spite of very wide fluctuations in signal strength. This set also employs a new heptode valve which enables the triple function of oscillating, detecting and automatic volume control to be carried out successfully.

Similar advances have been made in the battery sets. The superheterodyne set now has automatic volume control. In the smaller battery four valve straight set the tuned circuits have Gecalloy iron cores, which give the set the maximum possible selectivity, and circuits have been developed to give a very uniform sensitivity to the set.

In the smaller mains operated sets a great advance has been made by the development of a universal set which is contained in a moulded

bakelite cabinet. It is suitable for use on either A.C. or D.C. mains. For the smaller battery set a circuit has been adopted which eliminates the grid bias battery and automatically adjusts the bias to give the maximum output as the high tension battery runs down.

The oscillator testing equipment, which was installed last year, has proved its value in increasing the accuracy and in speeding up the testing of the sets, and has now been duplicated. In conjunction with the Research Laboratories a further test for selectivity was developed. The response curve of the selective filters used in the present sets is drawn out automatically on a cathode ray oscillograph, and any small departures from the true selectivity curve are at once apparent.

DESIGN OF LOUDSPEAKERS.

The trend of loudspeaker design has been to give increasingly good quality while preserving or enhancing the sensitivity. One direction in which this has been sought is by an increase in the frequency range both at the top and bottom ends of the scale, practical limits being set for low notes by the size of cabinet permissible, and at the top by the interference from outside sources. In the present conditions governing broadcast transmission it is inadvisable to reproduce all the upper harmonics of speech and music, as the gain in quality is more than offset by various forms of interference. In another direction attention has been given to detail improvements designed to eliminate the production of harmonics in the loudspeaker itself, particularly when operated at a high volume.

RADIO RELAY EQUIPMENT.

The distribution of broadcast programmes at audio-frequency to subscribers connected by wire to a central receiving point continues to find increased popularity both in Great Britain and abroad. An outstanding development in this field is a short-wave receiver specifically intended for use in territories in which interest is centred largely in the Empire programmes and in other short-wave transmissions.

The receiver is of the supersonic-heterodyne type, covering a wave-band of from 13 to 100 metres. It consists of a local oscillator, one stage of radio-frequency amplification, first detector, two stages of I.F. amplification, second detector, one stage of audio-frequency amplification and a valve providing automatic gain control. In fig. 83 a typical Colonial radio-relay station equipment is illustrated which comprises two short-wave receivers together with amplifiers and control apparatus. A driver panel amplifies the receiver output providing sufficient grid swing to operate the power output stages. In this particular station, serving some 500 subscribers, these stages have an A.C. output of 25 watts but for stations in which a greater output is required an amplifier having an output of 90 watts has been developed. This amplifier, termed the DA.100, is illustrated in fig. 84. Although designed primarily for use with radio relay equipment its scope is in no way limited to this application.

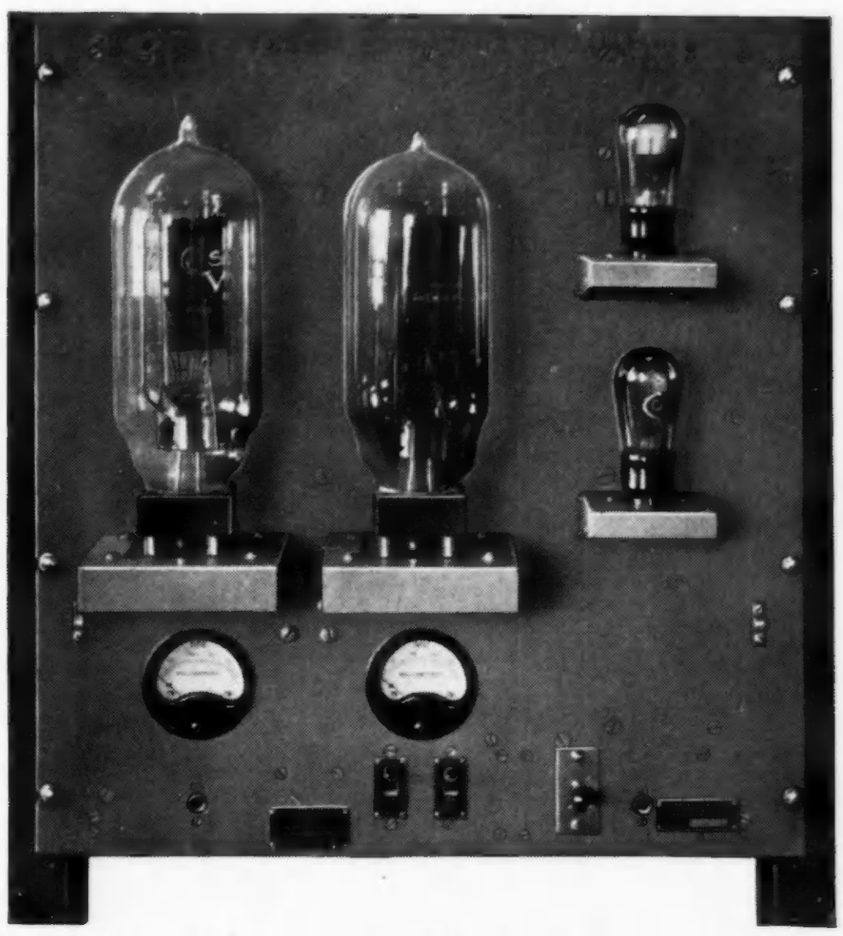


Fig. 84.—Amplifier panel, giving undistorted output of 90 watts.

BARRETTERS.

New practice in radio engineering practice has created the need for fine wire barretters for use in conjunction with "Universal" and D.C. mains radio receivers working on various supply pressures.

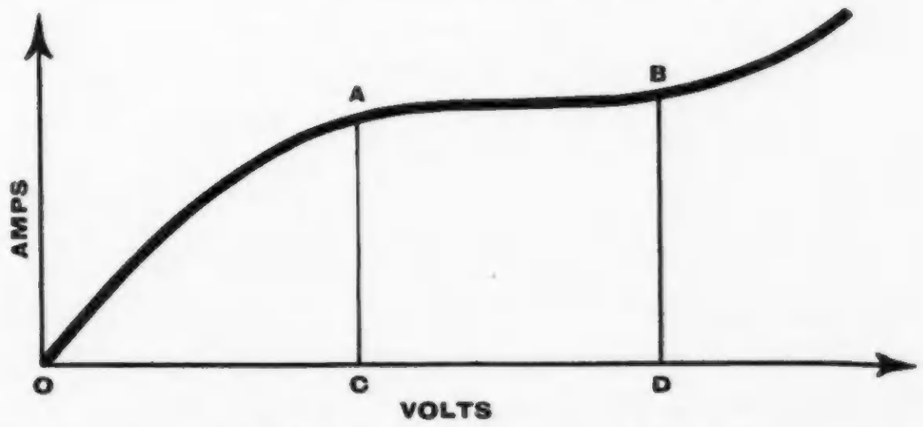


Fig. 85.—Typical characteristic curve of a barretter.

As the result of investigation at the Osram Lamp Works, a range of fine wire barretters is now available for use with radio receiving sets and similar apparatus.

A barretter is a well known device for maintaining constant current in a circuit although the applied voltage may vary over a considerable range. It usually consists of an iron wire resistance operating at just below the point of dull red heat in an atmosphere of hydrogen.

Iron is chosen for the purpose because it has a high temperature coefficient of resistance in the region of red heat, so that a considerable change in potential across it produces very little change in current. Hydrogen is used for gasfilling because of its high thermal conductivity, which enables it to maintain a steady control on the rate of energy dissipation.

The actual functioning of a barretter is readily understood by reference to a typical characteristic curve, fig. 85, where the current obtained is plotted

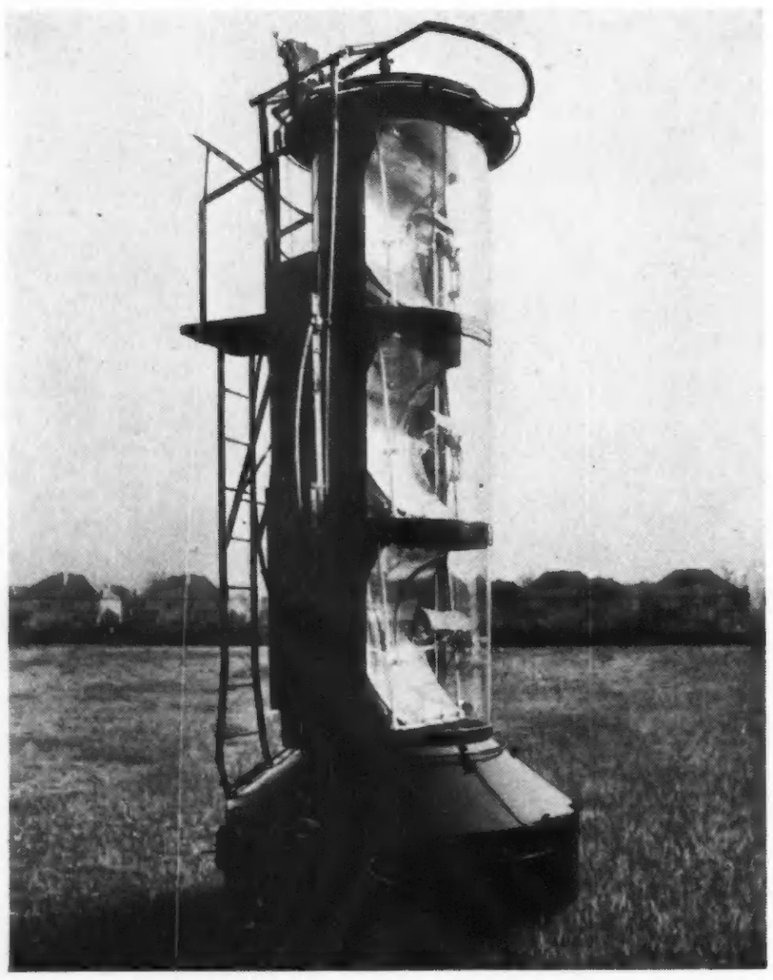


Fig. 86.—9 kW Aerodrome landing floodlight.

against the potential difference necessary to maintain it. As the volts across the barretter are increased to "C," the current increases to value "CA" afterwards, remaining fairly constant within narrow limits until a voltage "D" is exceeded, beyond which there is a steady rise.

In practice it is found that "OD" is approximately twice "OC" so that the useful range of a barretter of this kind is from 2—4v, 50—100v, etc., and the maximum current change over this range of volts is not more than $\pm$ 5%, and can usually be made much less. Barretters have been manufactured covering ranges between 0.2 amp. and 5.0 amps., and from 1 to 220 volts, the actual voltage range being determined in accordance with the method described above, but it is not practicable to combine the higher voltage variations with heavy current due to the difficulty of dissipating the watts generated.

Low wattage barretters are comparatively quick in correcting voltage variations, but as the watts increase so also does the time taken to reach a state of equilibrium from the moment of switching. This time lag is only a few seconds for small types but may be several minutes in large types; the total resistance of the associated circuit and its composition also affects this time lag.

Two points to remember in connection with barretters are, first, that external conditions which may effect the temperature of the glass envelope, such as draughts, will cause small changes in the characteristics, and secondly, that care should be taken to see that barretters have been switched off for a minute or so before handling, as the bulbs become very hot in use although there may be no visible indication that they are working.

Recent additions to the types available include the following :—

Osram Type.	Voltage Range.	Working Current.
204	86—129 volts	0.2 amp.
203	100—180 ,,	0.2 ,,
202	114—195 ,,	0.2 ,,
201	138—221 ,,	0.2 ,,
251	100—170 ,,	0.25 ,,
303	86—129 ,,	0.30 ,,
302	114—195 ,,	0.30 ,,
301	138—221 ,,	0.30 ,,

RECEIVING VALVES.

During the past year a complete new range of mains valves, the Universal Range, has been introduced. These valves employ a heater rated at 13 volts 0.3 ampere, which is suitable for A.C. or D.C. running or for radio receivers in motor cars. The choice of 4 watts for the cathode enables high efficiency to be obtained, while a current of 0.3 ampere is not excessive for D.C. receivers. Special attention has been given to the design of the heater system to ensure the maximum insulation between heater and cathode, and to eliminate the possibility of hum, thus making possible the design of a "universal" receiver for A.C. or D.C. with the valve filaments running in series. The Universal Range includes a triode (H.30), a variable-mu high frequency pentode (W.30), a power pentode (N.30), a rectifier (U.30), which may be used as a rectifier or voltage doubler, and, in addition, a heptode frequency changer (X.30). This last valve, combining the functions of detector and oscillator in a more efficient way than hitherto possible, also enables automatic volume control to be applied to this stage of the receiver. The W.30 and N.30 have been designed as "Catkin." A heptode has also been added to the range of 4 volt mains valves. In the battery valves a double diode triode (HD22), a heptode frequency changer (X.21) and double pentode (Q.P.21) have been included, and a new range of small valves, the "K" series, has been introduced. The double pentode (Q.P.21) enables high output to be obtained in battery receivers, with good quality reproduction and at the same time economy in the high tension current consumption.

RECTIFIER TYPE LIGHT SENSITIVE CELLS.

The photoelectric cells supplied by Salford Works are of the self-generating "rectifier" or "sperrschicht" type, and therefore require no excitation potential. When these cells are shunted by a low resistance (about 50 ohms) the current in the external circuit is closely proportional to the light falling on them, so that if a low resistance microammeter is substituted for the external resistance, it can be scaled in light units.

The response of the cell to light of different wavelengths throughout the spectrum is not exactly the same as that of the human eye. If, therefore, these cells are used to measure light from sources different in colour (different in spectral energy distribution) from that of the standard light source with which the cell and microammeter combination is calibrated, errors are likely to occur. This, of course, will apply when measuring light sources of the electric discharge types, and a suitable correction should therefore be applied to such measurements.

If the cell is exposed to light for prolonged periods temporary fatigue will occur, resulting in reduced sensitivity. For example, exposure to an illumination of 50 foot-candles for an hour would result in a fall in sensitivity of the order of 5 per cent.

The response of the cell to light is also affected by temperature to the extent of about 0.5 per cent per degree, so that for accurate work, unless it is used with a suitable compensating device, corrections should be made.

These cells are available in the following three sizes.

No. 1. Circular; effective aperture of cell approximately, $1\frac{3}{8}$in. diameter.

No. 2. Circular; effective aperture of cell approximately, $\frac{3}{4}$in. diameter.

No. 3. Rectangular; effective aperture of cell approximately $1\frac{1}{4}$in. by $\frac{5}{8}$in.

The output of No. 1 size when illuminated by light from incandescent tungsten gasfilled lamps operating at 2800°K is approximately as follows :—

External Circuit Resistance.	Current for 50 Foot-Candles.	Microamperes per lumen.
50 ohms.	230 microamperes	440
100 ,,	170 ,, ,,	320
200 ,,	130 ,, ,,	250

It should be noted as mentioned in the foregoing text, that only with 50 ohms external resistance will a sensibly linear relationship between incident light and photoelectric current be obtained.

Whilst the microamperes per lumen of the No. 2 and No. 3 cells will be approximately the same as those given above for the No. 1 size due to the reduced cathode area of the smaller cells the current output will be proportionally less.

PHOTOELECTRIC CONTROL OF AERODROME BOUNDARY LIGHTS.

It is essential that aerodrome obstruction and boundary lights should be switched on when daylight is poor or as darkness approaches in the evening, so that the pilot can see the boundary of the aerodrome and any obstruction in the vicinity. The application of the photo-cell to the control of these lights has been attended with success, and an illustration is given, fig. 87, of a floodlight fitting at Croydon Airport on which is mounted an obstruction light. The switching on of the obstruction light

Fig. 87.—Aerodrome floodlight with obstruction light controlled by photoelectric cell.

is controlled by a photocell amplifier mounted on the right-hand of the structure which operates so that the lamp comes on when daylight falls below a predetermined limit.

ESCALATOR CONTROL.

The mechanical wear and tear on the type of escalator which is in continuous use (*e.g.*, at Underground stations) is extremely heavy, and renewals and repairs are both expensive and difficult to carry out, owing to restriction of space. It is desirable therefore, to reduce this wear to a minimum by keeping the speed low when no passengers are on the stairs. At the lesser frequented stations there are slack periods and the photocell can be used to keep the speed down when no one is on the escalator. At the entrance to the stairway, a suitable lamp is installed to shine across the footway on to a photocell similarly mounted on the other side just below the handrail. When this beam is interrupted by the entrance of a passenger, the stairway is speeded up in several stages so that the passenger feels no shock and the escalator continues to run at a high speed until the

passenger has had time to reach the top. This is attained by means of a time delay device using a wireless valve. If other passengers come on to the stairway before the last one reaches the top, the time delay device resets, so that the high speed continues until the last passenger gets to the top, after which the low speed comes into operation. In this way, unnecessary wear is eliminated by keeping the speed low at slack periods.

LIFT GATE WARNING.

Equipment has been installed at Earls Court Underground station to give warning to passengers when the lift gates are about to close. This apparatus operates in the same way as a sound projector in a cinema. A band of film on which are recorded the words "Stand clear of the gates please" is arranged to pass across the light from a lamp, the beam being concentrated by a suitable optical system on to a photocell. The photocell is followed by an amplifier of conventional design with the usual moving coil speaker. Passengers approaching the gates therefore hear the warning; at the same time a sign "Gates Closing" is illuminated.

FLAMEPROOF ACCESSORIES.

Reference has been made earlier in this article to various examples of flameproof equipment for mining purposes, *e.g.*, telephones and switchgear, in the design of which great advances have been made. In addition it has to be recorded that various patterns of mine bells, pulls and pushes, rappers and the like have received the approval of the Ministry of Mines.

ELECTRIC LIGHT ACCESSORIES.

Many detail improvements have been made in the existing ranges of electrical accessories, while a close study of demand has led to the introduction of new lines of apparatus wherever a need was indicated; but it is possible in this article to mention only a few of the main features relative to electrical accessories.

A new simple type of switch and fuse distribution board can now be supplied for installations such as are employed in small business establishments. Various sizes are available for dealing with from two to eight final sub circuits.

A conduit box 2 inches in diameter has been introduced, to which can be fitted either a new small semi-recessed ceiling rose, a "Nipper" semi-recessed switch, or, alternatively, a 2-pin or 3-pin flanged 2 ampere socket outlet. This simplifies the number of patterns required to be stocked by the installation contractor for small wiring installations.

The "Nipper" switch introduced last year in surface and semi-recessed mounting patterns has been extended in range to include flush mounting types with brass dollies and rings for use with metal flush plates or bakelite dollies and rings where bakelite plates are preferred.

The range of single cord ceiling switches[14] is now made to include double pole single base types, and all patterns are now available either with brass covers finished in any desired colour, or alternatively with bakelite covers in brown or cream.

A departure has been made from the orthodox club or dumb-bell shaped dolly of brass covered switches, a new oval pattern being employed similar to that introduced three years ago for bakelite covered switches. This shape of dolly is made by a method for which patent application has been made; it is gradually replacing the earlier type on all G.E.C. tumbler switches.

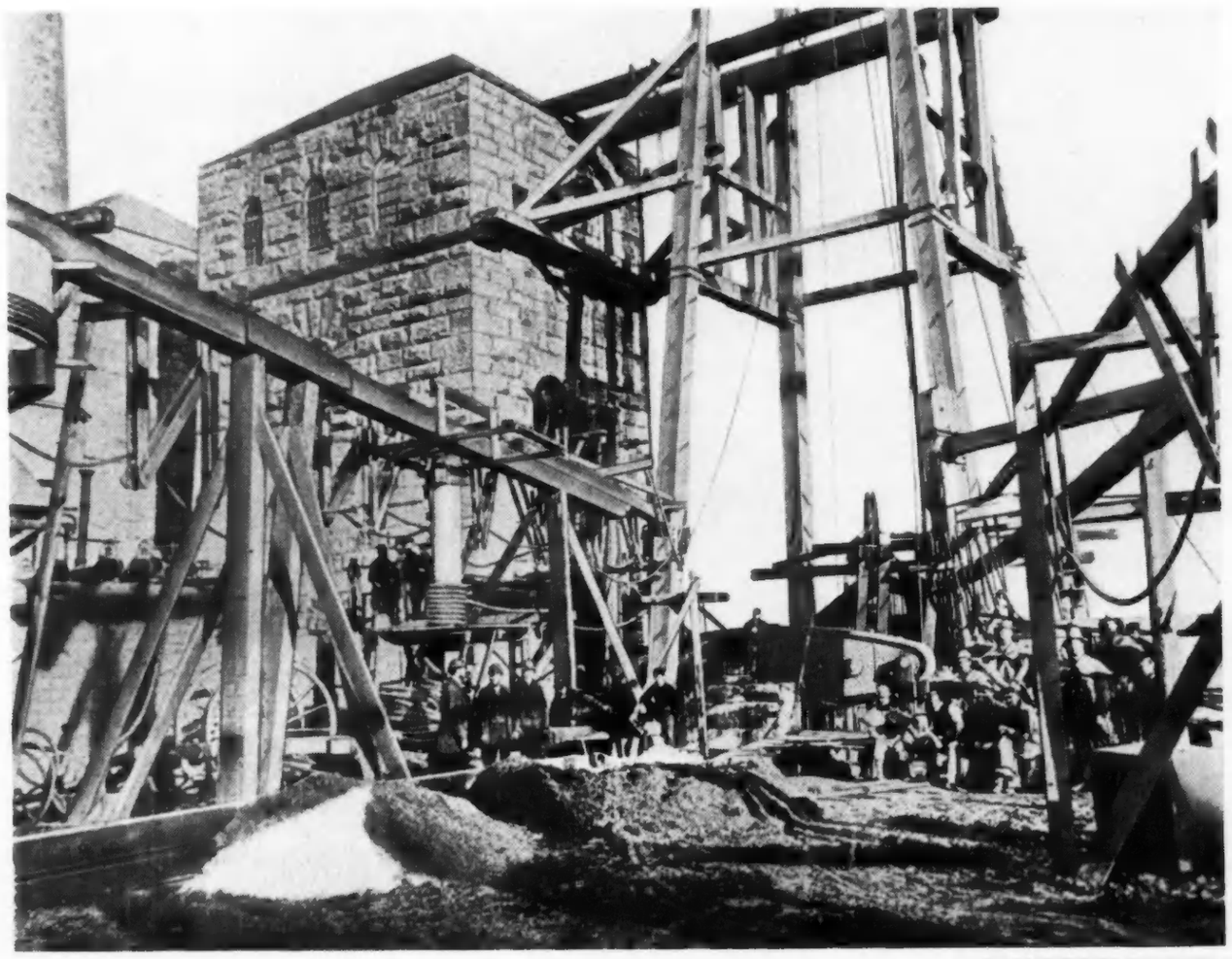
The range of switchplugs, both interlocking and non-interlocking, has been greatly increased to include all possible combinations, and the types available now include 85 different arrangements. One particularly interesting pattern is the dual purpose switchplug which consists of a 15 ampere double pole switch controlling a 15 ampere 2-pin socket outlet on one side and the provision of a 5 ampere 2-pin socket outlet on the other side (uncontrolled) and connected direct to the incoming sub-circuit mains. The object of this arrangement is that a radiator can be connected to the 15 ampere side and controlled by the switch, and a radio receiving set, an electric clock or other small current consuming device which requires to be permanently connected can be plugged into the 5 ampere 2-pin socket outlet. It is recommended that a double pole fused plug is used on this side so that should any fault occur in the flex connecting the appliance, or in the appliance itself, the local fuse in the plug offers complete protection to the wiring system.

Owing to the popularity of bakelite pattern lamp holders, there would appear to be little development required in brass patterns. In spite of this, however, a new pattern has been introduced. It consists of a $2\frac{1}{2}$ inch brass backplate with fixing holes at 2 inch centres for mounting direct to conduit boxes, made to British Standard Specification. The lampholder portion is fixed at an angle of 45 degrees on a dome shaped centre, mounted in the backplate in such a manner that the lamp can be swivelled to the desired position irrespective of the position of the fixing holes on the conduit box, after being fixed on or recessed in the wall.

In certain types of porcelain Edison lampholders, used mainly in lighting units, a departure has been made from the use of screwed ferrules for the reception of the Edison screwed lamp caps. This practice gave rise to the possibility of the ferrule being inadvertently connected to the live side of the wiring system. In the new design the porcelain itself is threaded, the metal ferrule thereby being eliminated. Contact on both poles is made practically simultaneously when the lamp is screwed right home.

(14) Patent No. 354911.

The Reconstruction and Electrification of Ryhope Colliery



By G. HINDSON,
Agent of
The Ryhope Coal Co., Ltd.

Two early views of Ryhope Colliery:

Fig. 1 (*left*).—**The sinking of the first pit, from a photograph taken in 1857.**

Fig. 2 (*below*). — **Ryhope Colliery on Dec. 30th, 1859, when the first train load of coal was despatched.**

THE electrification of Ryhope Colliery, Co. Durham, which was completed during the past summer, has involved one of the most notable colliery conversion schemes of recent years. It can only occur on the rarest possible occasions that a colliery, served through a period of more than seventy years by beam engine driven winders and other equipment belonging to a past generation, is transformed within a couple of years into one pcssessing throughout the most modern electrical equipment obtainable.

The old wooden headgears, winding engines and steam plant generally were very costly to maintain, and as a result of a careful survey of costs it became evident that definite economies could be effected by the adoption of a bold scheme. With a view to the total elimination of steam generation, plans were made for dismantling a battery of ten Lancashire boilers with economisers, superheaters and induced draught equipment, which were used for the operation of three large beam winding engines; also three steam driven air compressors with a steady load of 13,500 cubic feet of free air per minute which supplied underground haulages, coal cutters, etc. It was considered that the elimination of compressed air, so far as was possible, would provide one of the chief fields for economy, and it is interesting to note that the consumption of compressed air has been reduced from 13,000 to 3,000 cubic feet per minute. It is anticipated that in course of time further saving will be possible.

The scheme, as already indicated, was carried through in a period of two years, and in spite of reduced output owing to trade conditions, the savings achieved during the last twelve months have proved greater than originally estimated.

Before proceeding to a description of the conversion scheme and the new electrical plant and

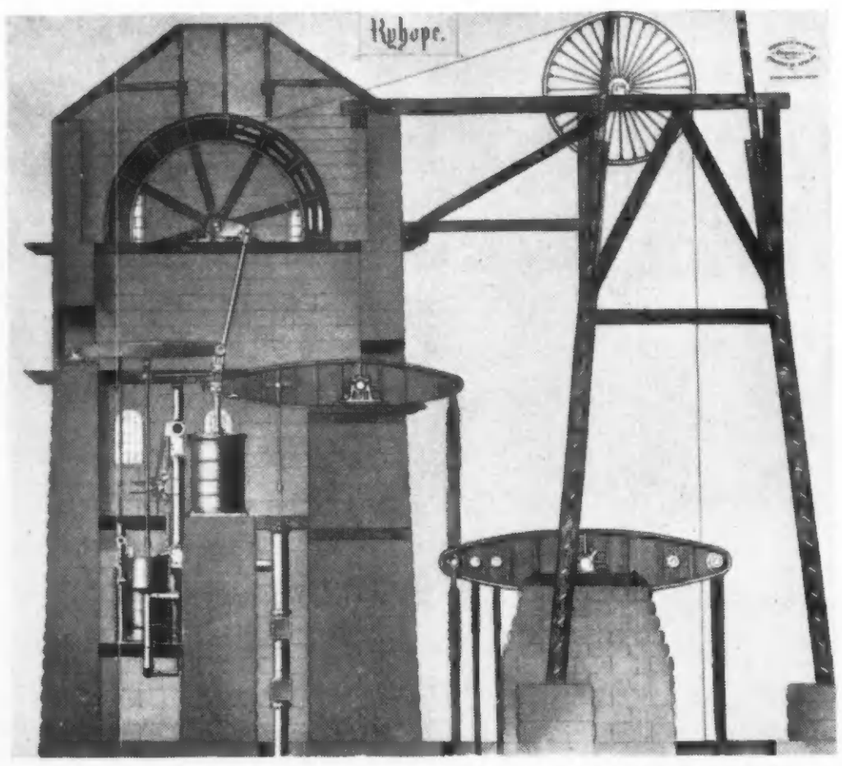


Fig. 3.—General arrangement of the first beam engine installed in 1855/6.

equipment which were installed, it will prove of interest to glance briefly at the early history of Ryhope Colliery and its beam engine equipment.

Carefully preserved records show that ground was broken for the sinking on April 10th, 1855, the mining engineer who executed the work of sinking and equipping the pits being the late John Taylor of Earsdon, an uncle of the present Chairman of the Company, Thomas Taylor, Esq., of Chipchase Castle, Northumberland. The earliest available photo of the initial operations—taken two years later—is reproduced at fig. 1. There had been serious difficulty with water, and the first winding engine, housed in the stone tower shown, was utilised for pumping. Subsequently, the sand bed was reached in February 1858, the pit was bottomed in 1859 (proving the Maudlin seam 11 ft. in thickness), and then on Dec. 30th of this latter year the first train load of coal was sent from Ryhope Colliery. This event, partly portrayed in fig. 2, was naturally

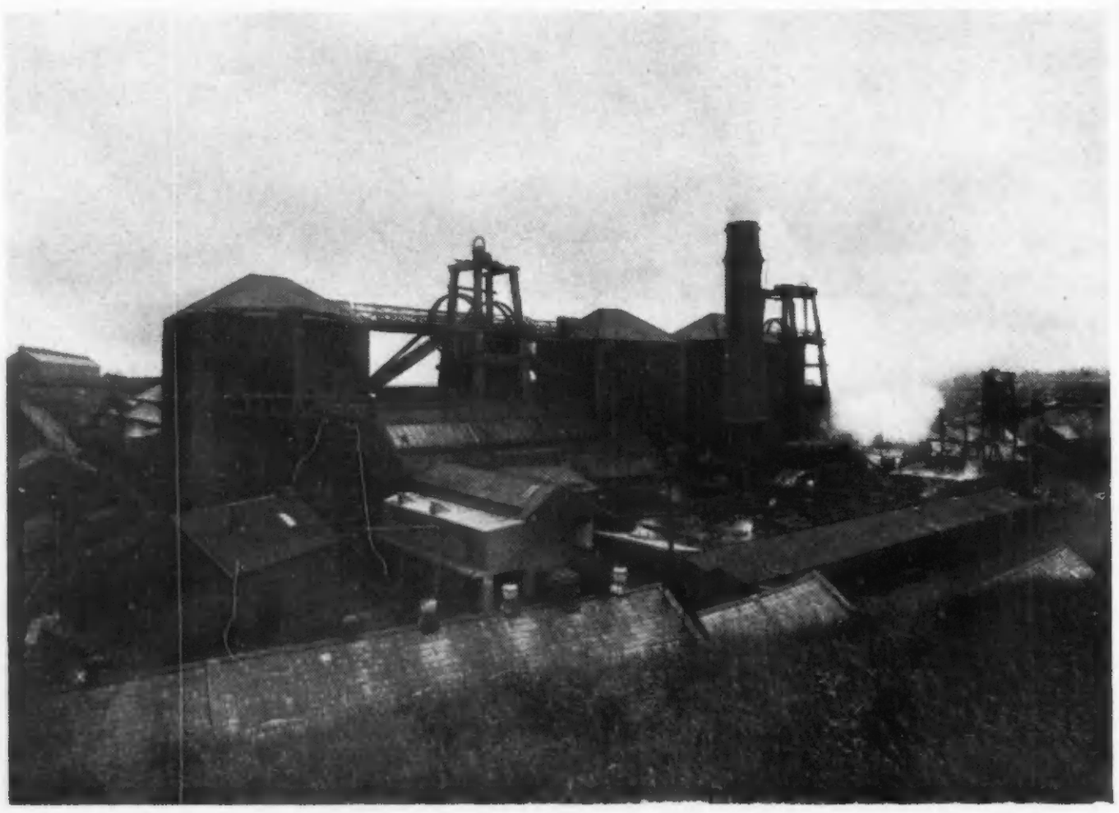


Fig. 4.—General view of the colliery just prior to the conversion scheme.

a cause for great rejoicing; flags may be seen on the top of the pit head gear. Unfortunately the trucks of coal do not appear, but history states that these were liberally beflagged for the occasion.

Steady development followed and in Oct. 1867, the sinking of a second pit was completed. The original shaft—"the upcast"—was known as the "South." The second shaft contained four cages

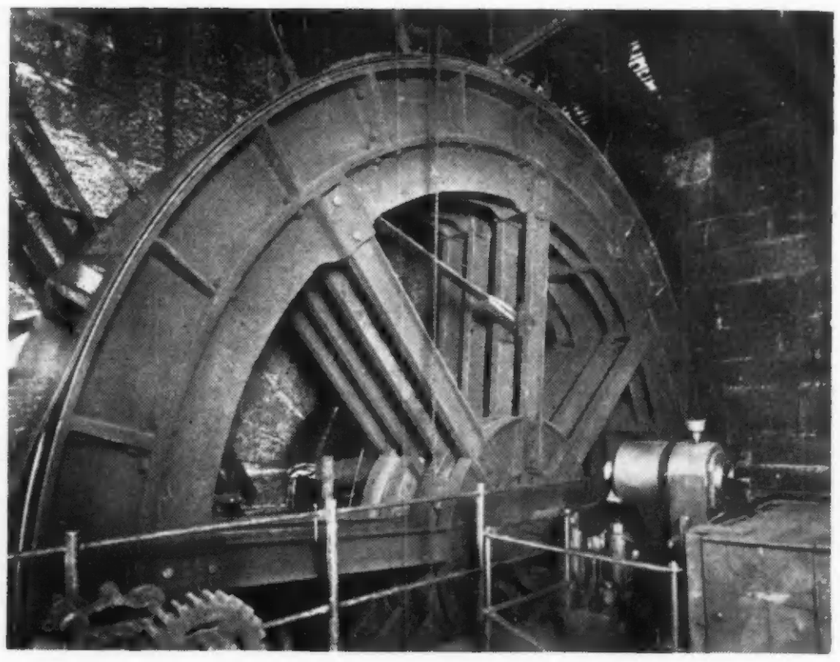


Fig. 5—Top end of connection rod and crank, also drum and band brake of West pit beam engine.

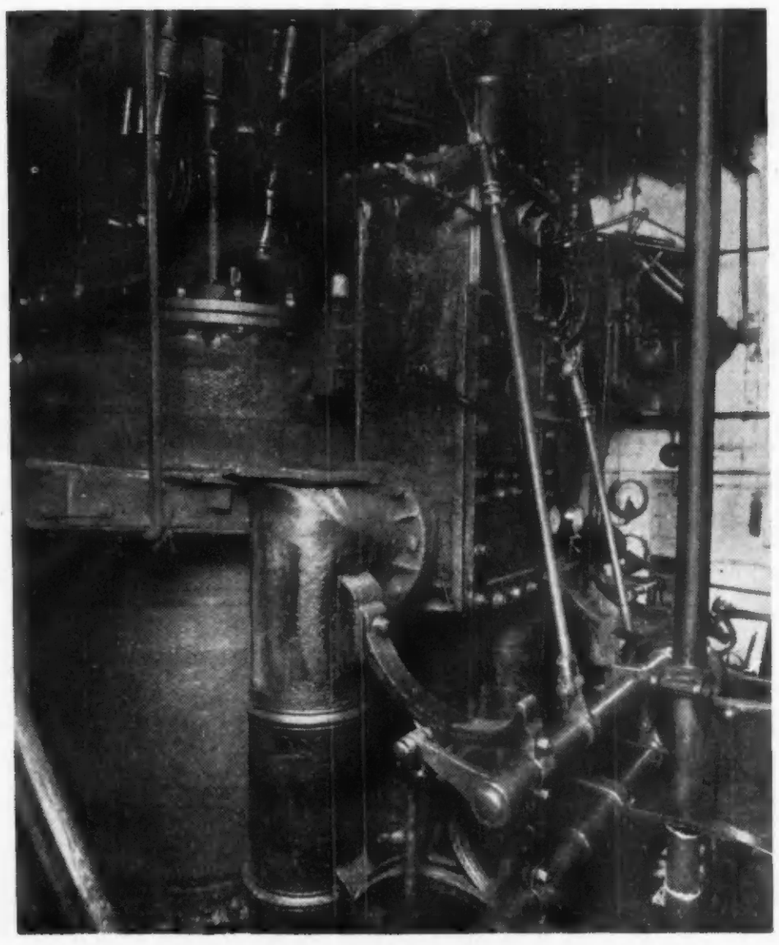


Fig. 6.—Part of West pit beam engine, showing cylinder, steam chest and valve gear.

with a winding engine on each side, these being styled the "West" and the "North" (or "Harvey"); this shaft is widened out at the middle to allow for the passing of the cages. The guides are of wood, the inside ones being splayed outwards towards the shaft side for some distance above and below "meetings" and while the inside cage has a straight lead, the outside

cage is forced off to one side to pass the other cage at meetings, after which it resumes a straight path.

The old winding engines were built by Thos. H. Murray of Chester-le-Street, Co. Durham, who established a great reputation as a builder of this type of engine two or three generations ago. At fig. 3 is reproduced an old drawing of the first of the engines to be installed.

The massive form of the stone tower in which the engines were housed may be seen in fig. 4 which shows a general view of the colliery as it was immediately before the conversion scheme was put in hand. The towers are 80 feet high and

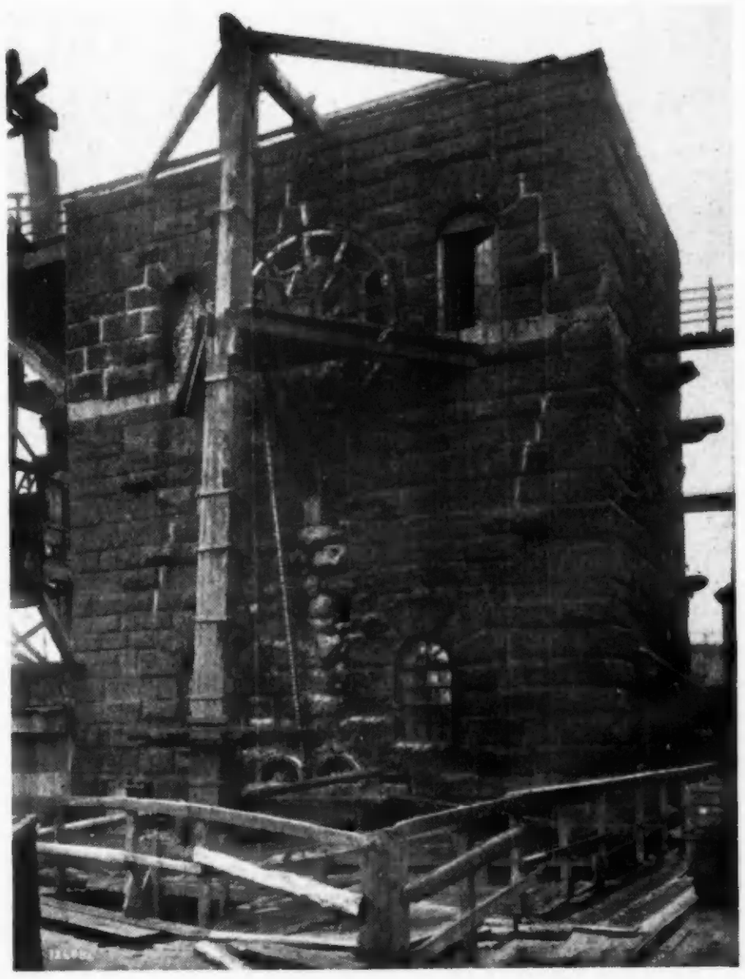


Fig. 7.—Balance chain drum on the outside of one of the engine houses.

40 feet square. Views of different parts of the West pit engine are given at figs. 5 and 6.

The three engines were generally similar, with cylinders of 68 inches diameter and a stroke of 84 inches. They ran at a speed of 18 r.p.m. and were supplied with steam at a pressure of 22 lbs. per sq. inch. It is of interest to note that flat ropes $4\frac{1}{2}$ inches wide by 1 inch thick were used for winding; they were naturally very heavy and costly in comparison with modern ropes, while the life proved to be of the order of 6 months, as compared with the expected life of three years obtained with modern ropes.

Fig. 8.—Progress made in the erection of the West pit head frame by June 9th, 1932.

A feature of the equipment of the engines was the balance weight drum, shown outside one of the stone engine houses, fig. 7. This drum is keyed on to the drum shaft. The flat chain attached to it, which is 35 fathoms long, is also clearly shown.

It is a wonderful tribute to the beam engine driven winders that the original output for which they were designed—namely 700,000 tons per annum—was maintained throughout their life, until they were taken finally out of commission.

Considering the conversion scheme as a whole the most important sections of the work consisted of the dismantling of the three old beam engines, the installation of three geared electric winders, and the erection of the new headgears. The last named task in particular presented great difficulties as the existing wood headgear had to remain intact to allow work in the pits to continue.

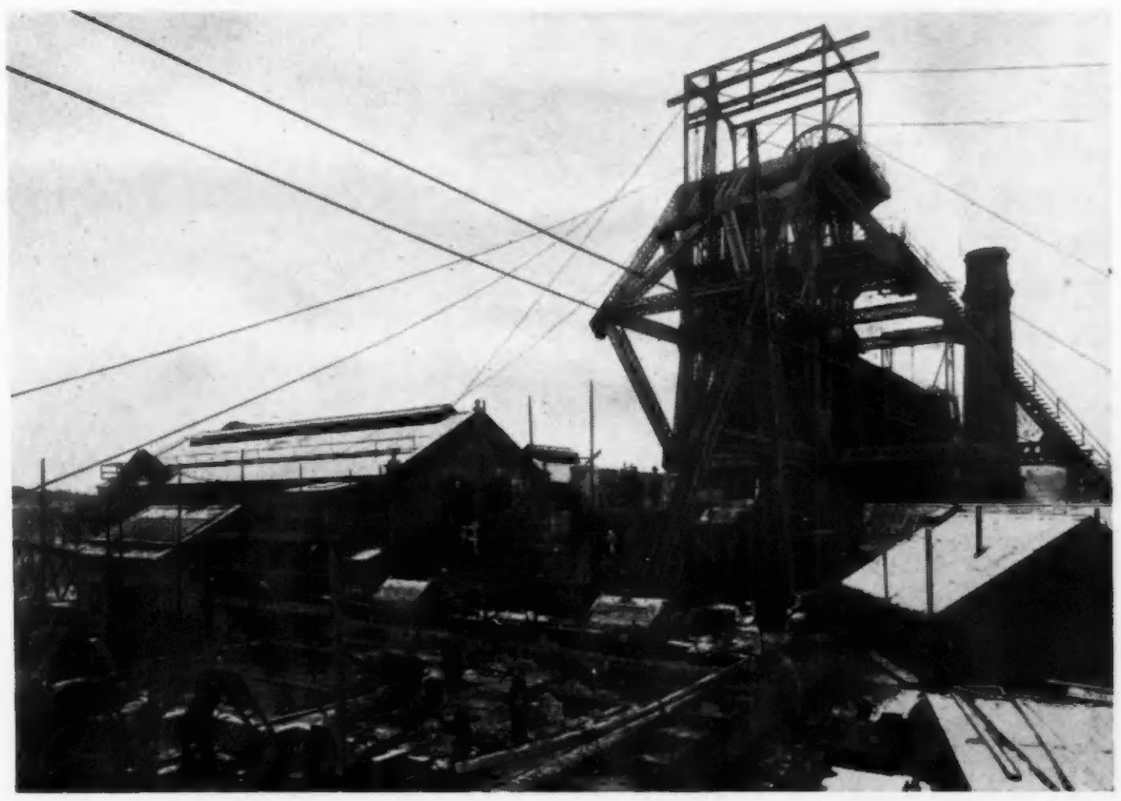


Fig. 9.—The Harvey and West pit head frames in the early days of 1933.

Even apart from the conversion of the winders and erection of new pithead gear the scope of the scheme was unusually comprehensive, the new electric plant which has been installed including over one hundred motors with appropriate motor control gear and starting apparatus (the total capacity of the motors is approximately 8,000 h.p.) complete main and auxiliary

Fig. 10.—The Harvey and West pit head frames as completed.

distribution switchgear, transformers, cables, etc. Of the cables, 14,000 yards were installed underground and 2,800 yards on the surface, making a total of 16,800 yards. The whole of the electrical equipment was designed and manufactured by the G.E.C. at Witton Works, the mechanical parts of the winder at Fraser & Chalmers Engineering Works, Erith, and the cable at Pirelli-General Cable Works, Southampton. The new headgear and cages were designed and erected by Jos. Cook, Sons & Co., Ltd. as sub-contractors to the G.E.C.

The difficulty of erecting the new head frames without disturbing the existing wood headgears has already been referred to. How successfully the task was accomplished is evidenced by the fact that not a single ton of coal was lost due to the erection. In order to facilitate the necessary operations a wooden model was built by the Ryhope Colliery Company upon a scale of $\frac{1}{2}$ inch to 1 foot showing the existing headgears with the new gears formed outside. It was found by experiment with this model that the erection could be carried out without interfering with the existing headgear and pulleys.

The Harvey and West pit winders which operate on a brattice shaft involved the construction of a combined headgear with the new winding engines placed at right angles. This was rendered necessary due to the congested state of the existing surface buildings. It would not be possible in this article to give a detailed description of the many steps which had to be taken before the erection was completed, but some of the more important stages will be referred to.

The clearing of the site for the foundations of the new legs was commenced on Nov. 1st, 1931, this being the first operation of the conversion scheme. Over 300 tons of rubbish were removed before it was possible to start digging foundations.

The headgear for these pits is of the lattice type, the main legs being 2 feet 3 inches square, the height

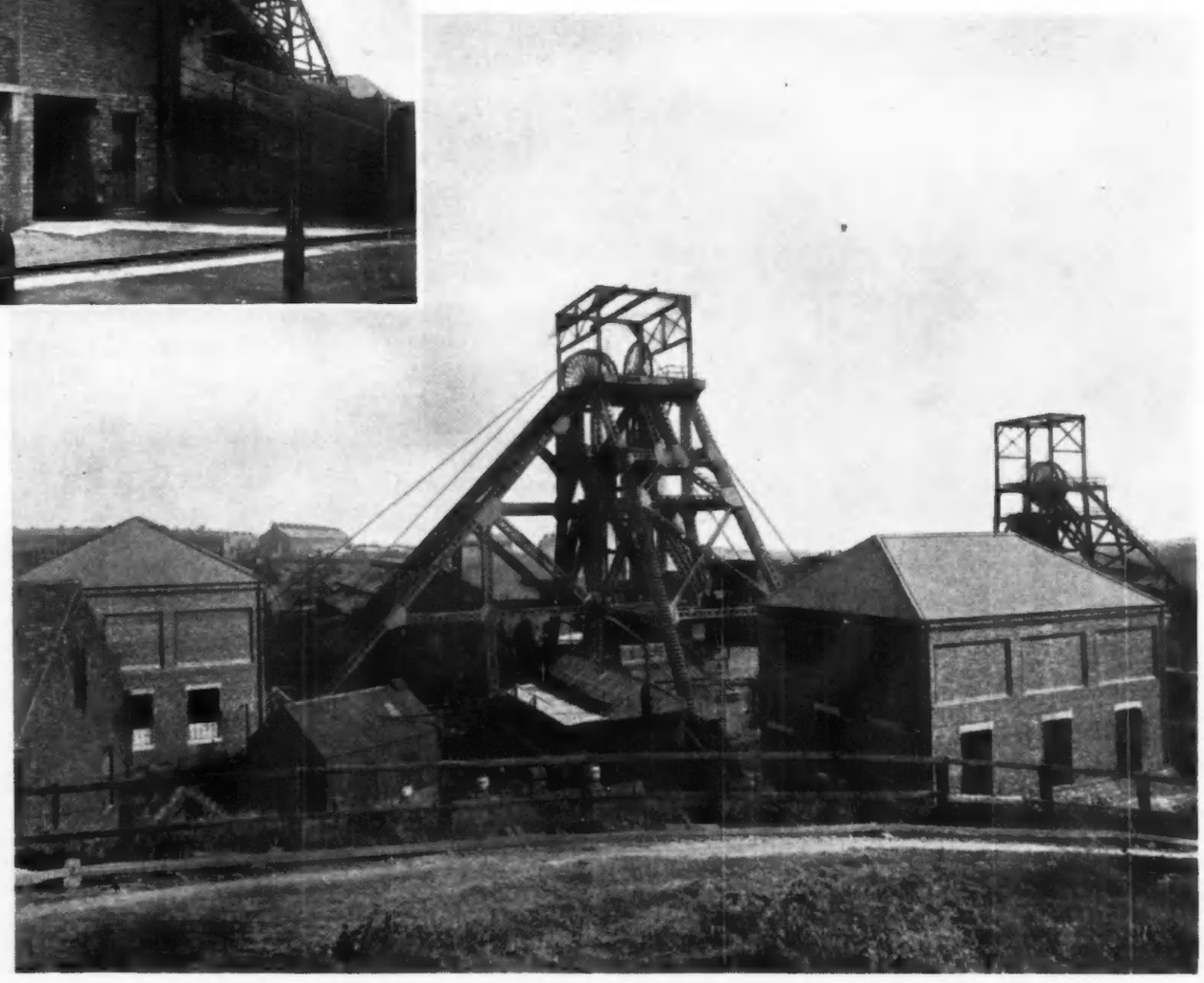


Fig. 11—A general view of the colliery from the southwest, when the conversion had been completed.

from the ground level to centre line of pulleys 103 feet, and the diameter of the pulleys 16 feet.

The pulleys for the Harvey Pit are side by side, while those for the West Pit are one above the other and at right angles to those for the Harvey Pit. The reason for this arrangement was that the existing steam winders were housed at each side of the pit in direct line; the West Pit electric winder had therefore to be built first, and this allowed the old steam winder and house to be demolished to form the site for the Harvey electric winder, leaving

the existing Harvey steam winder working during the construction of the new winder.

The setting out proved a most difficult problem as, owing to existing buildings and plant, direct centre lines could not be used; therefore a base line was formed and the whole of the structure set off from side lines, which proved absolutely correct on completion.

On Feb. 1st, 1932, foundations were commenced for main legs and at a depth of ten feet below ground level a good solid foundation was secured. Two hundred and twenty tons of concrete were required for the four foundations. Before the erection of headgear legs could be started, part of the existing heapstead roof had to be removed. On March 25th the first section of the main legs was fixed in position and by the beginning of May the rivetting of the base of the legs was started and preparations made to put in kep girders which were afterwards fixed in position.

At this point, on May 21st, 1932, the old cat gallows and jack pulleys on the old headgear had to be removed to facilitate the erection of the new headgears, and on June 27th, the top plates and cathead girders were erected. The general effect of the operations carried out up to this date may be seen in fig. 8; the photo which is reproduced was taken on June 9th. During the foregoing period, the rivetting of joints in the headgear was proceeded with. On June 2nd, a beginning was made with the erection of the back legs for the West pit; these were completed on Aug. 1st, all being lined up and the bases filled and levelled up with concrete. On Sept. 24th, the West pit pulleys were erected. On Oct. 17th a start was made in the erection of the top portion of the Harvey pit back legs. The old West pit keps and baulks were taken out on Nov. 29th, 1932, also the old wood framing removed, after which the rolled steel joists, stanchions and frame work for shaft framing were erected.

The West pit keps were finished on Dec. 20th, 1932, and a start was made with the erection of the framework below heap level. The bellgirders for the West pit were erected in the early days of 1933. A view of the undertaking as it was on Jan. 19th, taken from the S.E. is shown at fig. 9. The West pit winder and headgear was by this time ready for service when required.

During the erection of the headgear below heap level, the Harvey keps and framing had to be temporarily placed $4\frac{1}{2}$ inches out of true position to suit the old cages and guides. Then after the change over to electric winding which took place on the 3rd/6th June, 1933, the keps and framing had to be moved again to their correct position to suit the new four-deck cages which were installed soon after. The head frames of the Harvey and West pits as completed are seen in fig. 10.

Meantime the excavation of the foundations of the engine houses for the winding engines for these pits had been in progress. The erection of the West pit winder was commenced on Oct. 1st, 1932, and by Nov. 4th, the engine was run light. The erection of the Harvey pit winder was commenced on April 4th, 1933, the engine being run light on May 10th.

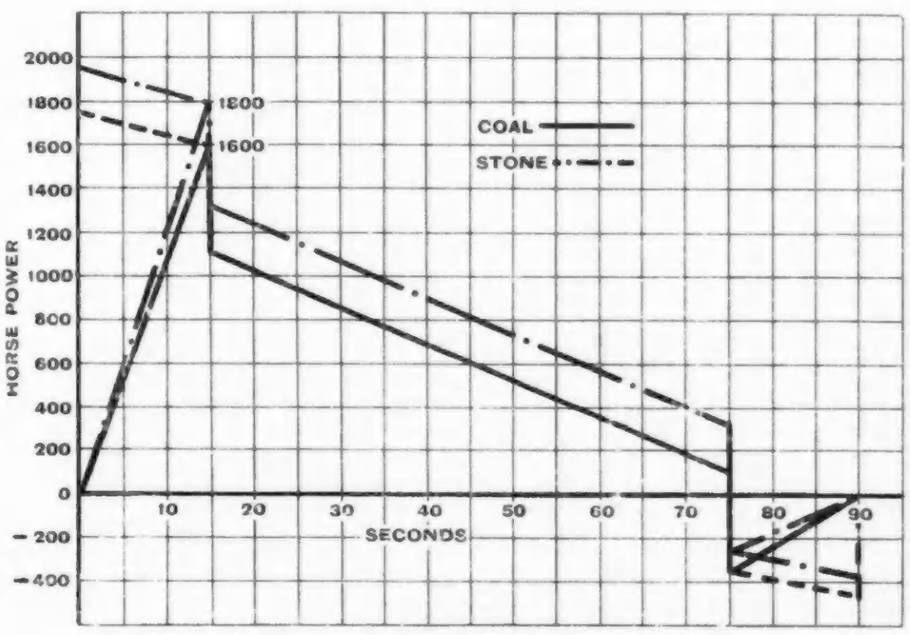


Fig. 12.—Input load diagram for Harvey pit winding engine.

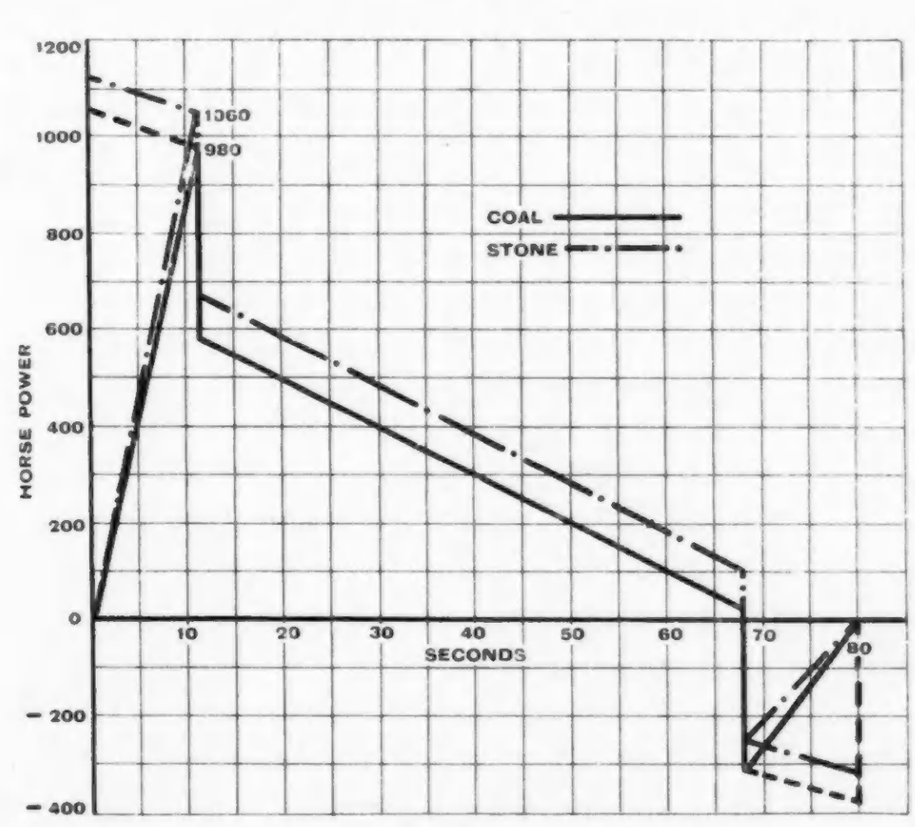


Fig. 13.—Input load diagram for West pit winding engine.

Both ropes were run on to drums ready for sockets on May 27th, 1933. On Whit. Saturday, June 3rd, 1933, the change over from the old steam winder was started; the old pulleys were taken down in ten hours and the old timbers framework and bell baulks were taken down in eight hours. The ropes were then pulled over from the new electric winder, this work being stopped from time to time owing to the lowering down of old timbers. At 9.45 p.m., June 4th, 1933, the first rope was socketted and by 2.30 a.m., June 5th, the second rope was socketted. After connecting the ropes to the cages the winder was run with coal and stone

by 8 p.m., June 5th, 1933. The engine was run from this time until 2 a.m., June 6th, to stretch ropes after which it commenced coal work with the original two deck cages.

On July 8th, 1933, the removal was begun of two deck cages which were taken out at flat sheet level, and the new four deck cages were put in from ground level. Before this was done a template was tried down the shaft and the tight places on the existing wood brattice removed. The second cage was in by 3 p.m. on July 9th, 1933, and after cutting ropes and re-socketting the job was ready for trying out by 7.15 p.m. The cages were run through the shaft and all was clear for the pit by 10 p.m., July 9th, 1933.

The erection of the South pithead gear, for obvious reasons, did not present problems of the same nature as those which had to be solved in connection with the other pit head frames. The general methods of erection of the headgears were similar, but the main dimensions somewhat different, the height from the ground level to the centre line of the pulley being only 78 feet. The pulleys are of 16 feet diameter. The necessary operations—corresponding closely to those already described in the case of the other pithead frames—proceeded steadily and eventually the change over was completed so that the South pit winder was ready for service by 7 p.m. on Aug. 7th, 1933.

Before proceeding to a description of the electric winding engines it should be mentioned that electric power for the colliery supply is taken from the 11,000 volt mains of the North Eastern Electric Supply Co., Ltd. It is transformed by two 3,000 kVA transformers to 2,750 volts.

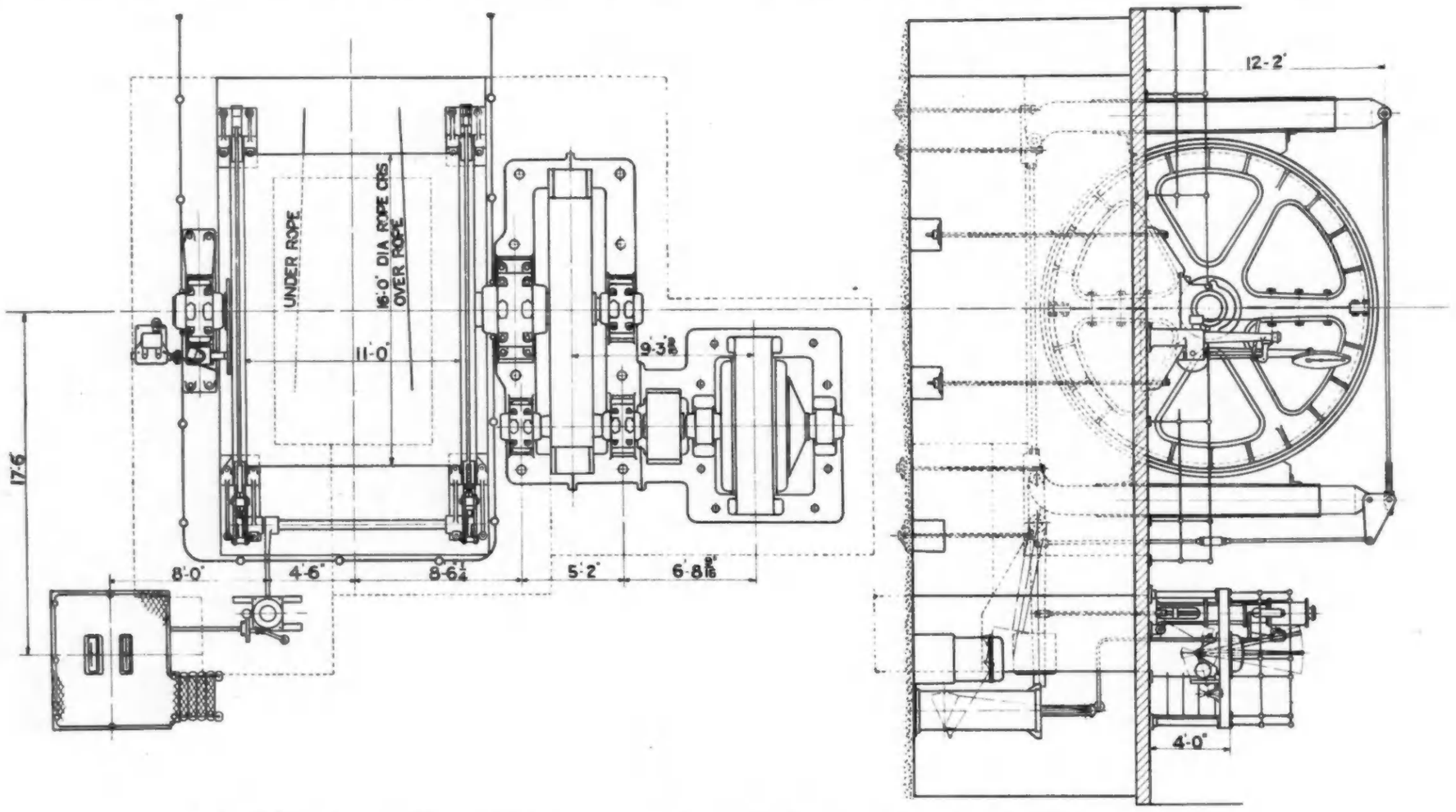


Fig. 14.—General arrangement of the winding engine at the Harvey pit.

The main details of the electrical winding engines are given in the following table, it will be observed that the requirements of the West and South pits are of the same order, and for this reason the winding equipments are duplicate.

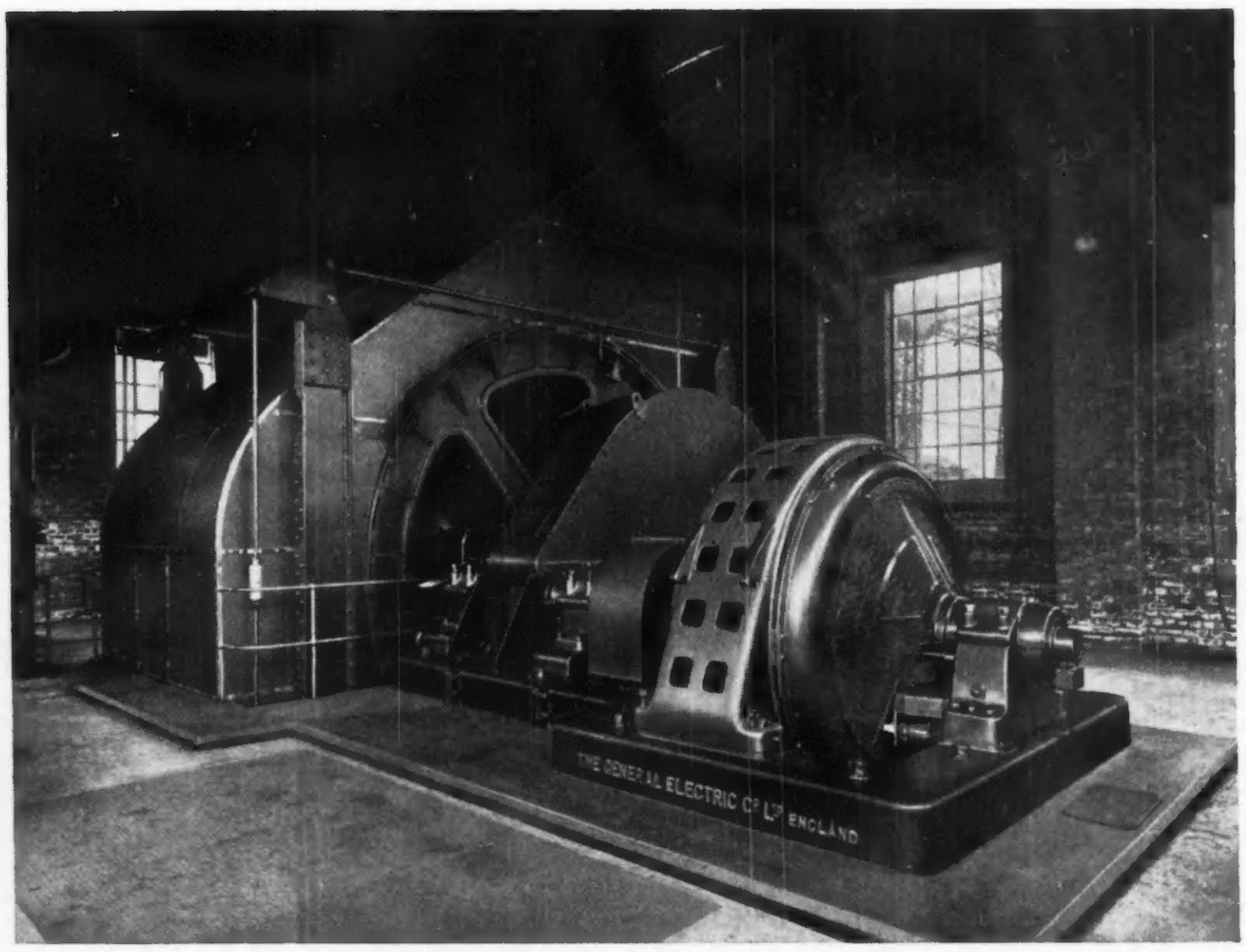


Fig. 15.—General view of Harvey pit winder driven through gearing by 875 h.p. induction motor.

	Harvey Pit.	West Pit.	South Pit.
Depth of wind	1830 ft.	1650 ft.	1550 ft.
Weight of coal	9860 lbs.	4920 lbs.	4920 lbs.
,, ,, stone	13400 lbs.	6720 lbs.	6720 lbs.
,, ,, cage	14500 lbs.	7300 lbs.	9200 lbs.
,, ,, tubs	6720 lbs.	3360 lbs.	3360 lbs.
,, ,, rope	13400 lbs.	6950 lbs.	6550 lbs.
Drum inertia	120000 lbs./ft.^{2}	33000 lbs./ft.^{2}	33000 lbs./ft.^{2}
Time of acceleration ..	15 secs.	12 secs.	15 secs.
,, ,, retard	15 ,,	12 ,,	15 ,,
,, ,, wind	90 ,,	80 ,,	79 ,,
,, ,, decking	22½ ,,	30 ,,	20 ,,
Rope speed	1465 ft./min.	1460 ft./min.	1460 ft./min.
Drum speed	29 r.p.m.	38.7 r.p.m.	38.7 r.p.m.
H.P. of winder motor ..	875/1400	500/800	500/800
Motor speed	290 r.p.m.	290 r.p.m.	290 r.p.m.
Units per wind	10.2	6.2	5.5
Distance in rope plane ..	137 ft.	135 ft.	140 ft.
Rope lead at start of wind	1 in 48.8	1 in 41.8	1 in 73
,, ,, ,, end ,, ,,	1 in 40.2	1 in 54	1 in 40.7

The horse-power time diagram in fig. 12 refers to the Harvey pit winder, and that shown at fig. 13 is for the West pit winder. This latter diagram corresponds very closely with that for the South pit winder.

The arrangement of the Harvey pit winder is shown in fig. 14 and a view of it as installed in fig. 15. It is laid out with a bedplate for the motor and gears and a soleplate for the outer bearing; both bedplate and soleplate are of cast iron.

All the bearings are of the ring oiling swivelling type which compensates for shaft deflections; this is particularly necessary in the case of the pinion shaft where the deflection is alternately up and down owing to the reversing nature of the drive.

The motors are of the dual frequency reconnect type, each motor being coupled to the drum shaft of the winder which it is driving through single reduction gears which have double helical machine cut teeth and are enclosed in an oil-tight case.

Fig. 16.—View from the driver's platform, West pit.

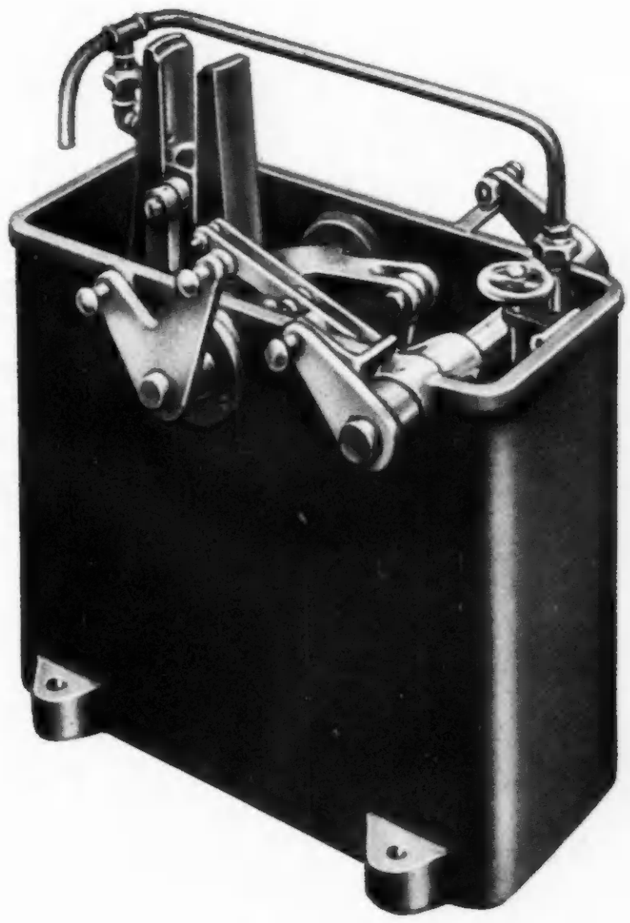


Fig. 17.—View of device designed to regulate acceleration of winding engines.

The diameter of the drum is 16 ft. and its width 11ft. It is constructed of cast iron cheeks made in halves, the joint being made at half arms. The brake paths are cast in one with the cheeks and are provided with mild steel liners. They are ventilated with air spaces between the liners and casting, the spaces being spirally formed to increase air circulation.

It has been the practice on the N.E. coast to provide the drum with oak lagging which allows the rope to form its own tread. In this case however, the drum shell itself is grooved for the rope and is made thicker to withstand the full crushing force of the rope, with additional strengthening by compression rings inside the shell. This construction has been utilized successfully by the G.E.C. in many parts of the world in cases where wide inside and outside angles have been encountered.

The brakes are of the straight post type swung at the lower end and lined with Ferodo. They are operated from a differential compressed air engine. The brake force is actually given by dead weight, but the intensity of braking corresponds to the difference between the dead weight

and total pressure in the engine. This pressure is controlled from the driver's brake lever which is connected to a variable pressure valve mounted on the brake engine.

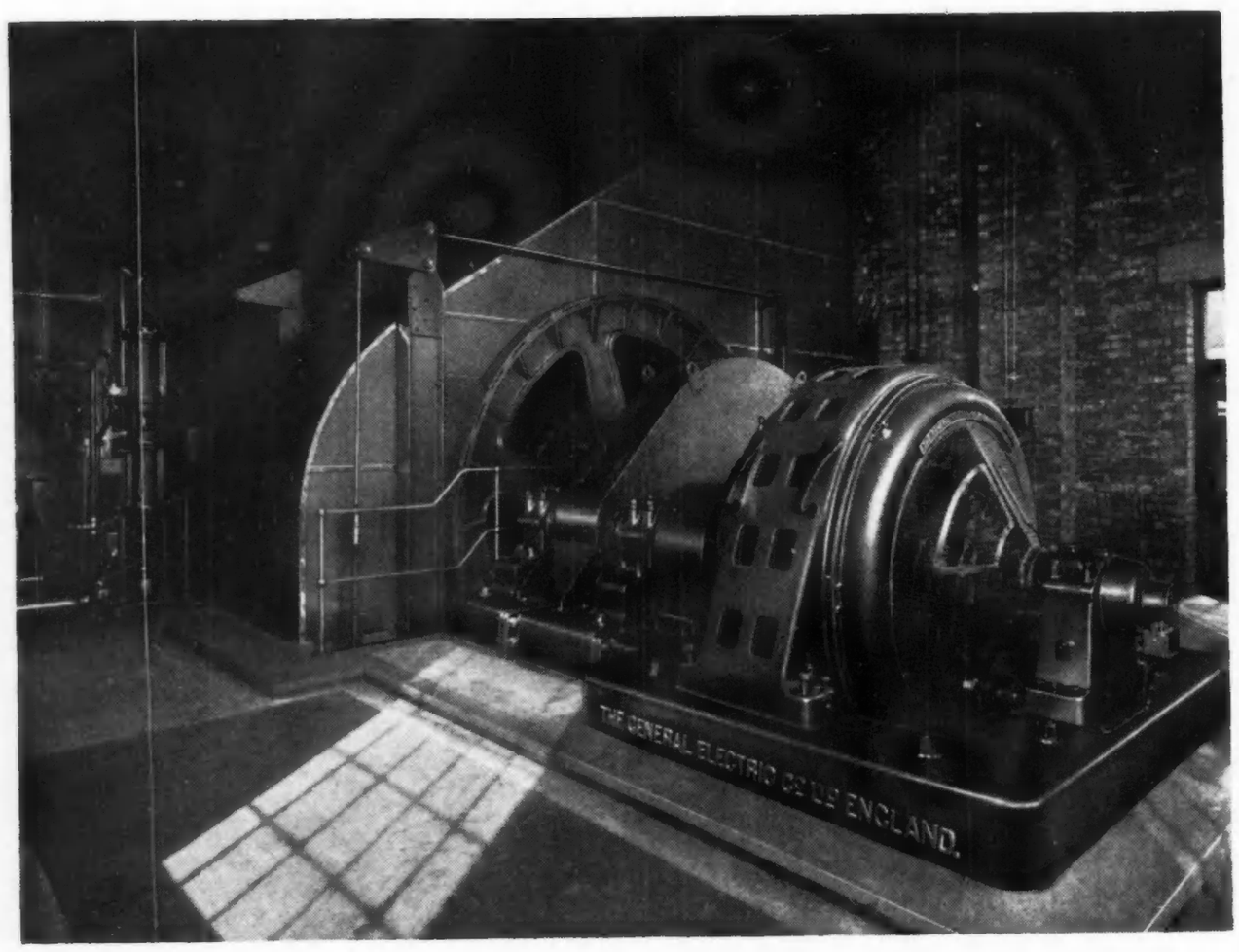


Fig. 18.—General view of South pit winder driven through gearing by 500 h.p. induction motor. (The West pit winder is identical).

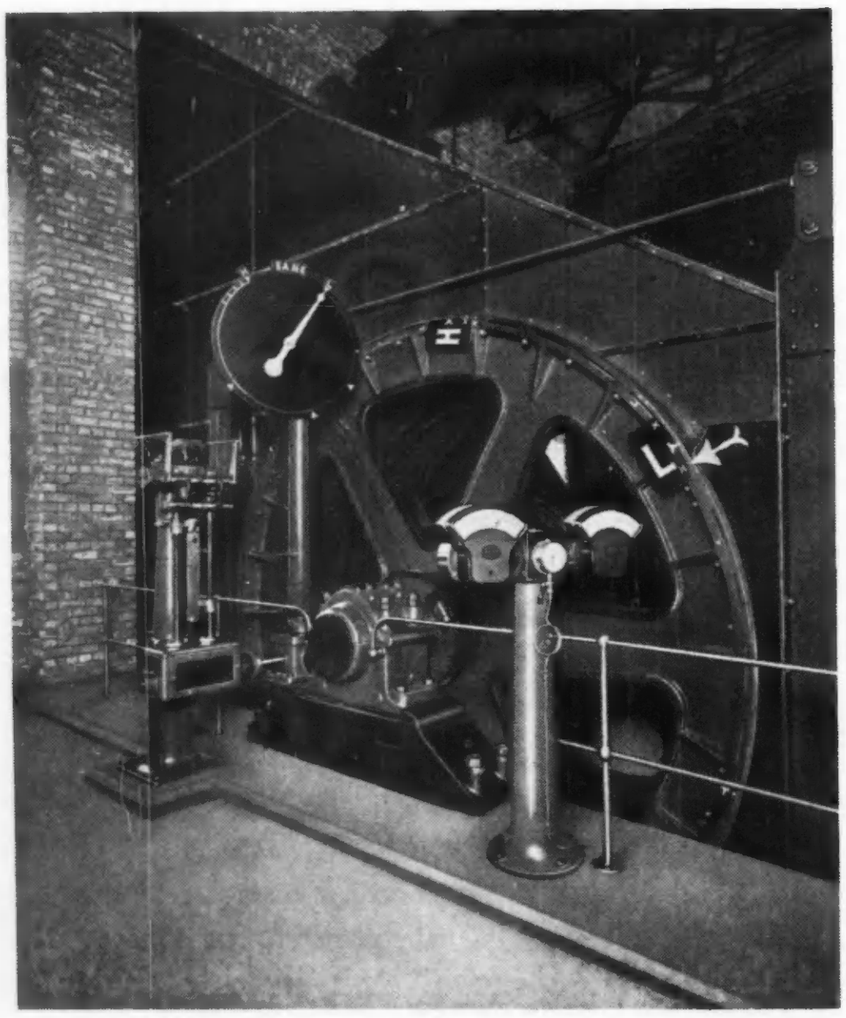


Fig. 19.—South pit winder, instrument pillar and depth indicator.

Protection against overwind is provided for by an improved type Whitmore overwinder which incorporates the new "landing zone" controller. This device gives additional protection against approaching banking level at a dangerous speed, and comprises a hydraulic cylinder with pistons arranged vertically. The piston is normally at the top of the cylinder, but at the point of deceleration it is released. The velocity of the piston downwards gradually decreases, and if the winder does not decelerate at the same rate a trip switch is operated.

This device works in conjunction with the safety control gear, which operates in case of current failure, air failure, or by hand emergency lever. The safety gear comprises a magnetic latch equipment which, in event of one of the above emergencies operating, is released. This operation through the appropriate switches and levers cuts off the current to the motor and applies the brakes.

A dial type depth indicator is provided mounted in front of the driver. The dial is 3 ft. in diameter and the pointer is driven through gearing from the drum shaft.

The control platform is raised above the floor level and the driver's levers and instruments are mounted and grouped so as to afford ease of operation.

A new feature which has been introduced is an automatic accelerating device, fig. 17, which is connected between the driver's control lever and the controller. This mechanism comprises a power unit operated by compressed air. It automatically regulates the rate of acceleration to any predetermined value, and in addition, relieves the driver entirely of manual effort. The control lever can be moved immediately from neutral to full "on," but the unit moves the controller only at the predetermined rate. If it is desired to accelerate only to half speed, or any other speed, the driver moves his lever by the appropriate amount and the unit moves the controller at the predetermined rate to the corresponding position.

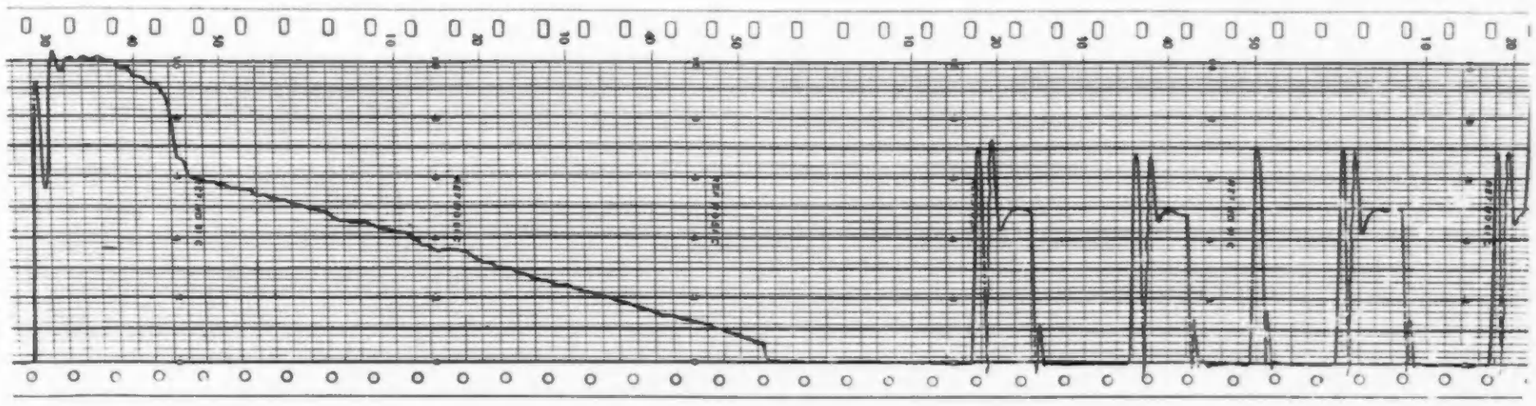
The controller is also returned to "off" position by the unit when the control lever is returned to neutral. The return speed, however, is entirely controlled by the driver, as the rate of return of the controller is the same as that of the driver's lever. The power required to move the controller is, of course, given by the unit in either direction of movement.

The introduction of this unit represents one of the most recent improvements in the control of winding engines.

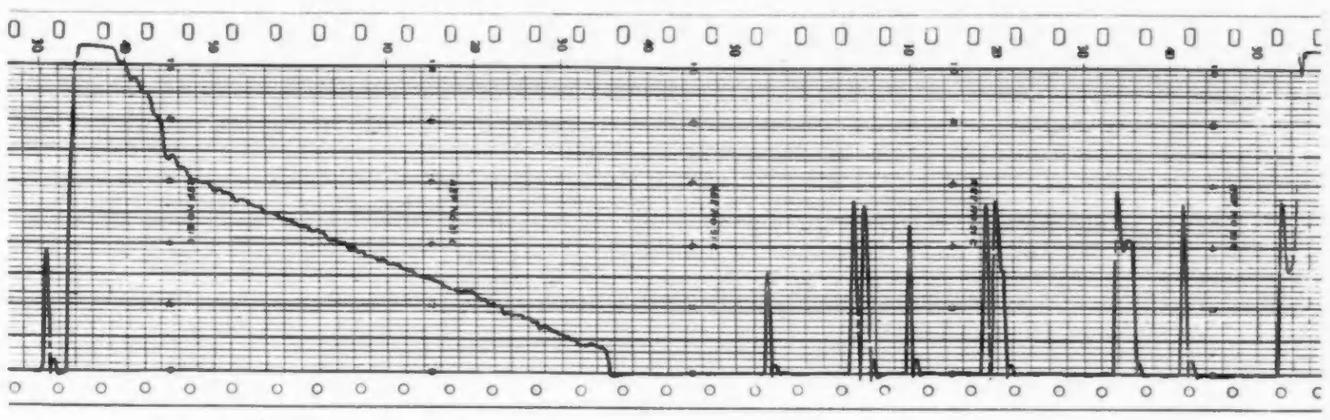
The West and South pit winders are similar

in construction to the Harvey pit winder, but they are, of course, smaller, the drums being 12 ft. in diameter by 7 feet with other parts correspondingly smaller.

each decking operation the unbalanced weight of rope had to be lifted. It was naturally realized that this system would have to be altered, but before any change was made a wattmeter curve,



(20 a).



(20 b).

Fig. 20.—Curves of decking of 4-Deck cage of Harvey pit winder.

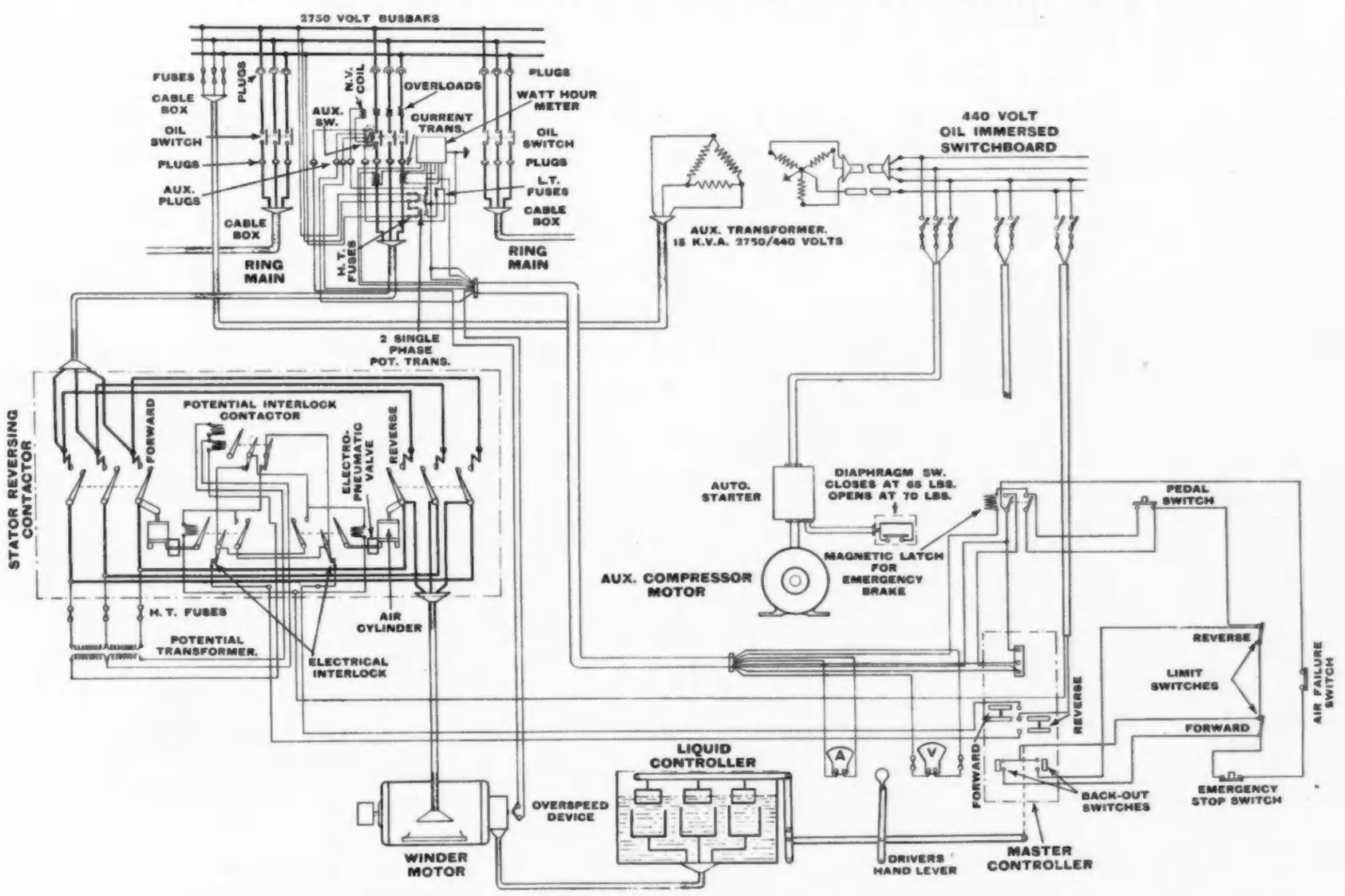


Fig. 21.—Diagram of connections illustrating control of winders.

Views in the South pit winding houses are given at figs. 18 and 19.

With the system of decking employed before the conversion the bottom deck of the ascending 4-deck cage was decked first. This meant that for fig. 20a, was taken. From this curve it is evident that an unduly large amount of energy was consumed during the decking operation.

In the system introduced at the time of the conversion the top deck of the ascending 4-deck

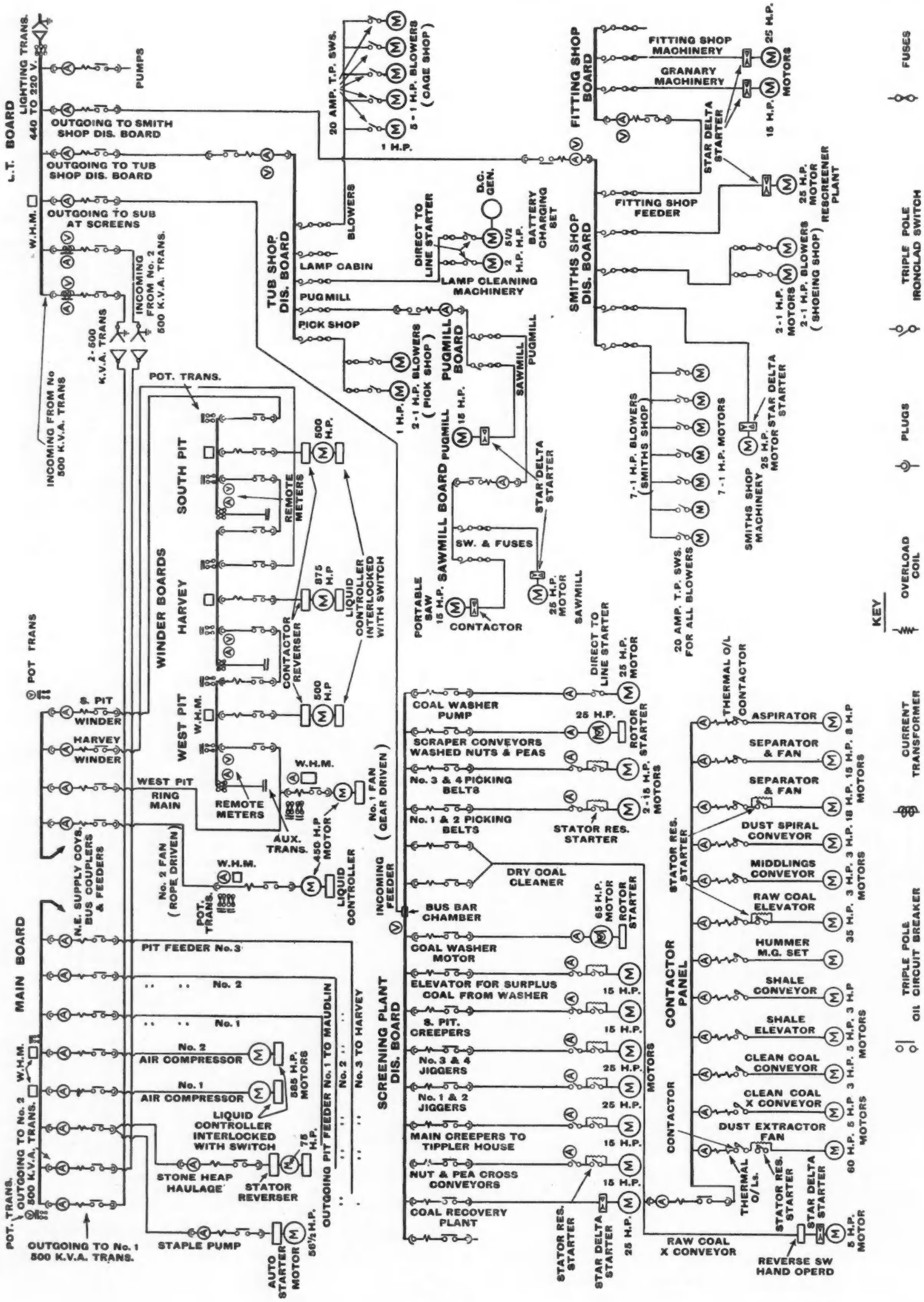


Fig. 22.—Diagram of connections of surface plant.

cage is decked first. The wattmeter curve obtained with this method in use is shown at fig. 20b. The improvement obtained is obvious, 2½ units per trip being saved. It should be pointed out, however, that the curves were taken before the equipment was operating at its maximum efficiency. At a later date it is the intention of the colliery management to adopt simultaneous decking which will further reduce the consumption per wind.

The winder motors are supplied on the double ring main system, whereby each winder can be supplied from an independent source. The scheme of control is shown in fig. 21, while fig. 22 gives a diagram of connections of the surface plant.

A stator reverser of the air break contactor type arranged for pneumatic operation is employed, fig. 23.

In order to ensure that the contactors close without shock, the air lines to the pneumatic valves are equipped with chokes, which reduce the initial air pressure but permit the pressure to rise to its full value when the stator contactors are in the closed position. Electrical and mechanical interlocks are provided, so that it is impossible to close the forward and reverse contactors together. An auxiliary contactor and transformer between the main contactors prevent the operating coils of

Fig. 22.—Diagram of connections of surface plant.

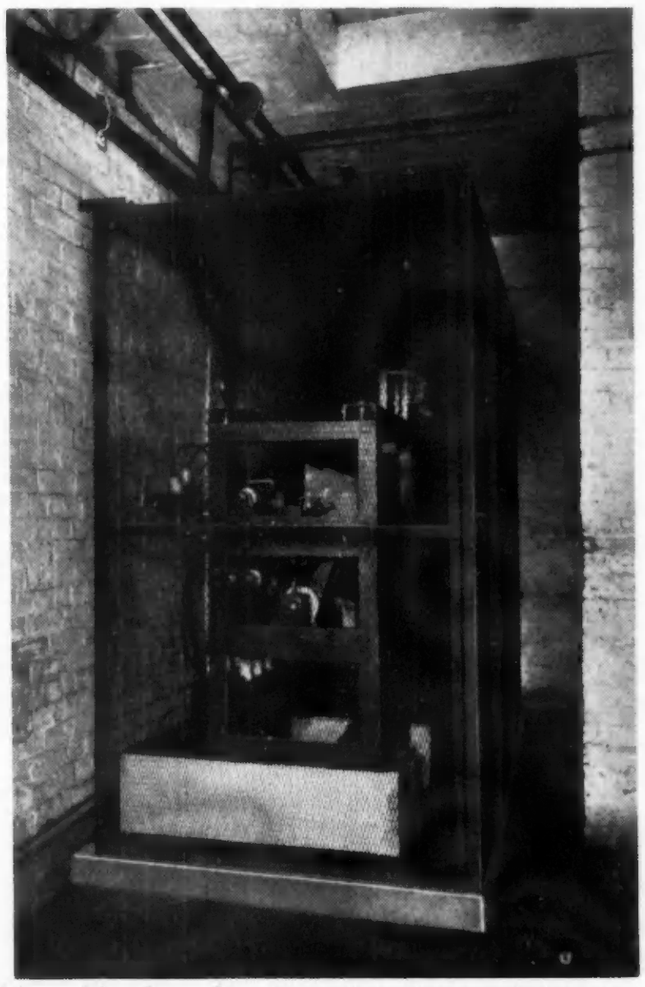


Fig. 23.—Air-break contactor type stator reverser employed in control of winding motors.

either set of electro-pneumatic valves from being energised so long as there is any voltage across the motor terminals. This is an important feature, as it ensures that the arc is completely cleared before the contactors can close and complete the circuit for reversing the motor.

The electro-pneumatic valves are actuated by contacts in a master controller mechanically coupled to the driver's hand lever, so that the initial motion of the latter, in either direction away from neutral, causes the corresponding contactor to close.

Other contacts in the master controller, in conjunction with auxiliary switches on the brake

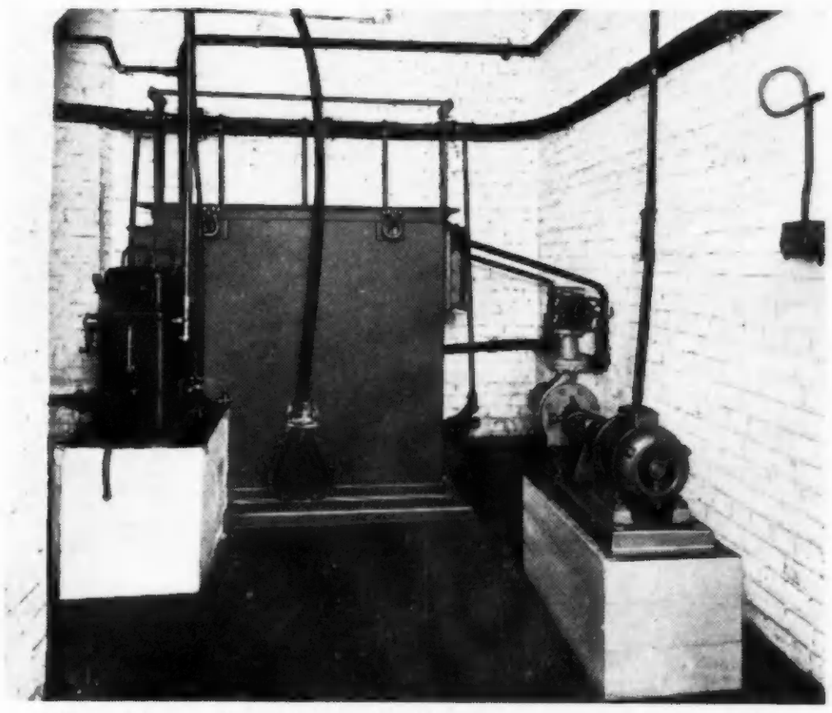


Fig. 24.—Liquid controller as used for winder motor control.

gear and main oil switch, ensure (1) that the oil switch cannot be closed unless the driver's hand lever is at "stop," and (2) that the emergency brake cannot be released unless the service brake is first applied.

Limit switches prevent dangerous overwinding in either direction, and operate in conjunction with "back-out" switches on the master controller, in such a manner that, after an overwind, it is only

Fig. 25.—A section of the 2,750 volt main switchboard, oil-immersed drawout type, installed in the compressor house.

possible to back out. The re-setting of the back-out switches is automatic and the backing out operation can be carried out by the driver alone.

The main electricity power supply, as stated above, is taken from the 11,000 volt mains of the North Eastern Electricity Supply Co., and transformed to 2,750 volts. The supply at this latter voltage is controlled by a pedestal oil immersed switchboard

divided into two sections which are situated on either side of the N.E.E.S. incoming bus couplers and feeders. The section to the left, fig. 25, controls incoming supply compressor motors, three feeders to the Maudlin and Harvey pits, Stone Heap haulage motor, and pump motors, also the supply to 500 kVA transformers from the L.T. side of which 440 volt supply is taken to a further oil immersed pedestal board. The other section of the 2,750 volt board supplies the winding motors and

by reference to figs. 22 and 26. Fig. 22 shows the distribution from the main switchboard, the surface equipment and pit feeders; fig. 26 shows the auxiliary switchboards and distribution scheme below ground; the cable roads and location of electrical plant in the Harvey pit, West pit and South pit, respectively, are shown in fig. 27.

The smaller motors in the installation are inter-frequency machines and the large ones are dual frequency reconnect type machines, in either case

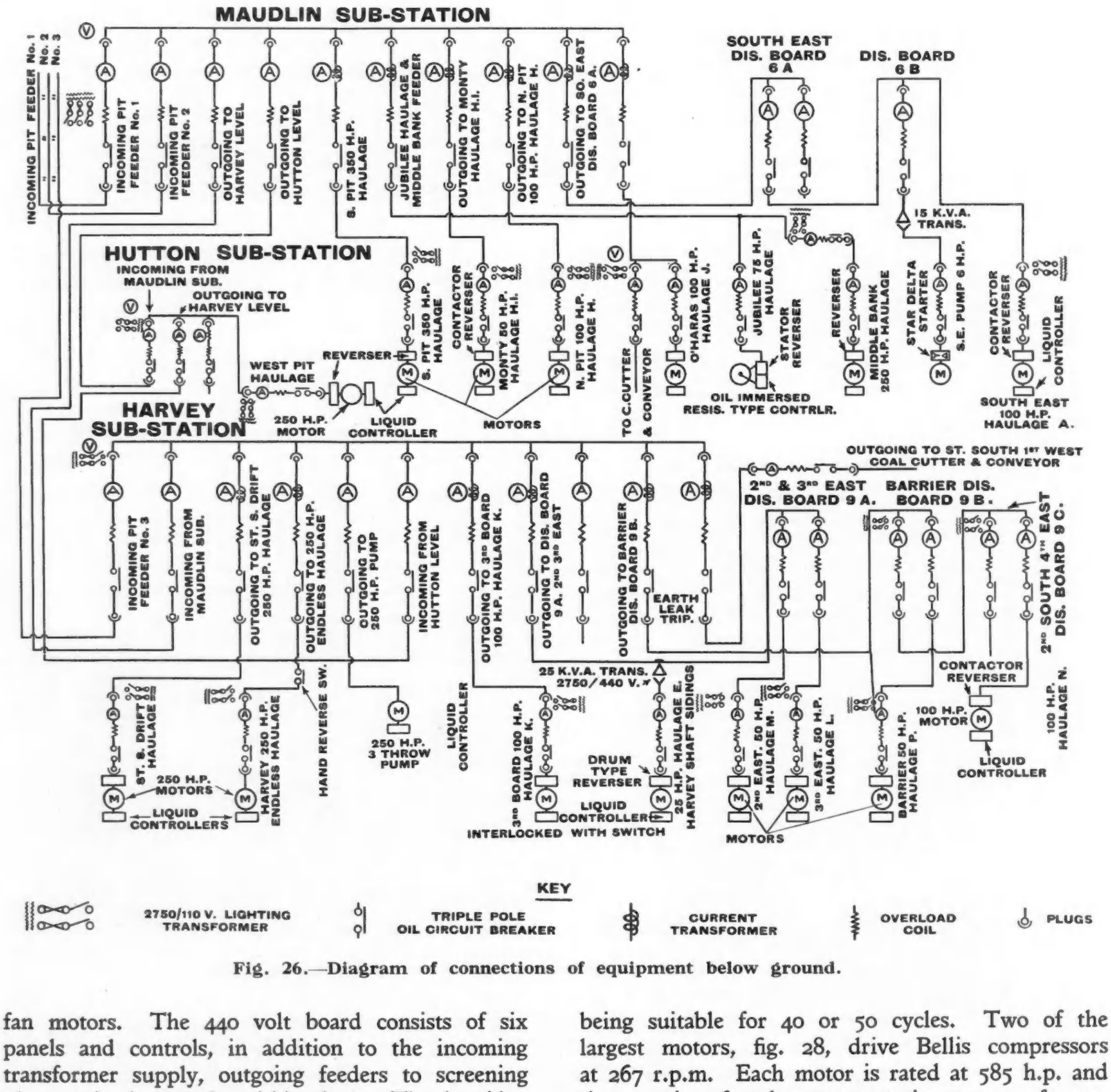

MAUDLIN SUB-STATION
INCOMING PIT FEEDER No. 1 No. 2 No. 3
INCOMING PIT FEEDER No. 1
INCOMING PIT FEEDER No. 2
OUTGOING TO HARVEY LEVEL
OUTGOING TO HUTTON LEVEL
S. PIT 350 H.P. HAULAGE
JUBILEE HAULAGE & MIDDLE BANK FEEDER
OUTGOING TO MONTY HAULAGE H.I.
OUTGOING TO N. PIT 100 H.P. HAULAGE H.
OUTGOING TO SO. EAST DIS. BOARD 6 A.
SOUTH EAST DIS. BOARD 6 A
DIS. BOARD 6 B
15 K.V.A. TRANS.
HUTTON SUB-STATION
INCOMING FROM MAUDLIN SUB.
OUTGOING TO HARVEY LEVEL
S. PIT 350 H.P. HAULAGE
CONTACTOR REVERSER
MONTY 50 H.P. HAULAGE H.I.
N. PIT 100 H.P. HAULAGE H.
TO C.CUTTER & CONVEYOR
O'HARAS 100 H.P. HAULAGE J.
JUBILEE 75 H.P. HAULAGE
STATOR REVERSER
OIL IMMERSED RESIS. TYPE CONTRLR.
REVERSER
MIDDLE BANK 250 H.P. HAULAGE
STAR DELTA STARTER
S.E. PUMP 6 H.P.
CONTACTOR REVERSER
LIQUID CONTROLLER
SOUTH EAST 100 H.P. HAULAGE A.
WEST PIT HAULAGE
REVERSER
250 H.P. MOTOR
LIQUID CONTROLLER
MOTORS
HARVEY SUB-STATION
OUTGOING TO ST. SOUTH 1ST WEST COAL CUTTER & CONVEYOR
2ND & 3RD EAST DIS. BOARD 9 A.
BARRIER DIS. BOARD 9 B.
2ND SOUTH 4TH EAST DIS. BOARD 9 C.
INCOMING PIT FEEDER No. 3
INCOMING FROM MAUDLIN SUB.
OUTGOING TO ST. S. DRIFT 250 H.P. HAULAGE
OUTGOING TO 250 H.P. ENDLESS HAULAGE
OUTGOING TO 250 H.P. PUMP
INCOMING FROM HUTTON LEVEL
OUTGOING TO 3RD BOARD 100 H.P. HAULAGE K.
OUTGOING TO DIS. BOARD 9 A. 2ND 3RD EAST
OUTGOING TO BARRIER DIS. BOARD 9 B.
EARTH LEAK TRIP.
25 K.V.A. TRANS. 2750/440 V.
CONTACTOR REVERSER
100 H.P. MOTOR
LIQUID CONTROLLER
100 H.P. HAULAGE N.
ST. S. DRIFT HAULAGE
250 H.P. MOTORS
LIQUID CONTROLLERS
HARVEY 250 H.P. ENDLESS HAULAGE
HAND REVERSE SW.
250 H.P. 3 THROW PUMP
LIQUID CONTROLLER
3RD BOARD 100 H.P. HAULAGE K.
DRUM TYPE REVERSER
LIQUID CONTROLLER INTERLOCKED WITH SWITCH
25 H.P. HAULAGE E. HARVEY SHAFT SIDINGS
2ND EAST. 50 H.P. HAULAGE M.
3RD EAST. 50 H.P. HAULAGE L.
BARRIER 50 H.P. HAULAGE P.
MOTORS
KEY
2750/110 V. LIGHTING TRANSFORMER
TRIPLE POLE OIL CIRCUIT BREAKER
CURRENT TRANSFORMER
OVERLOAD COIL
PLUGS

Fig. 26.—Diagram of connections of equipment below ground.

fan motors. The 440 volt board consists of six panels and controls, in addition to the incoming transformer supply, outgoing feeders to screening plant, tub shop and smith's shop. The breaking capacity of the oil circuit breakers on the 2,750 volt boards is 50,000 kVA, and on the 440 volt circuit 25,000 kVA.

The control and distribution of electric power throughout the colliery undertaking may be followed

being suitable for 40 or 50 cycles. Two of the largest motors, fig. 28, drive Bellis compressors at 267 r.p.m. Each motor is rated at 585 h.p. and the capacity of each compressor is 3,000 cu. ft. at a pressure of 80 lbs. per sq. in. It is of interest to note that these compressor sets supplanted three steam driven Ingersoll Rand units, two of which had been installed about 1890 and one in 1922.

The motors driving the apparatus comprising

the screening plant are either 15 h.p. or 25 h.p. totally enclosed squirrel cage machines. With one exception they are controlled by stator resistance starters which are push button operated. One of the motors driving the picking belts, is seen with its starter in fig. 29. Space forbids more than

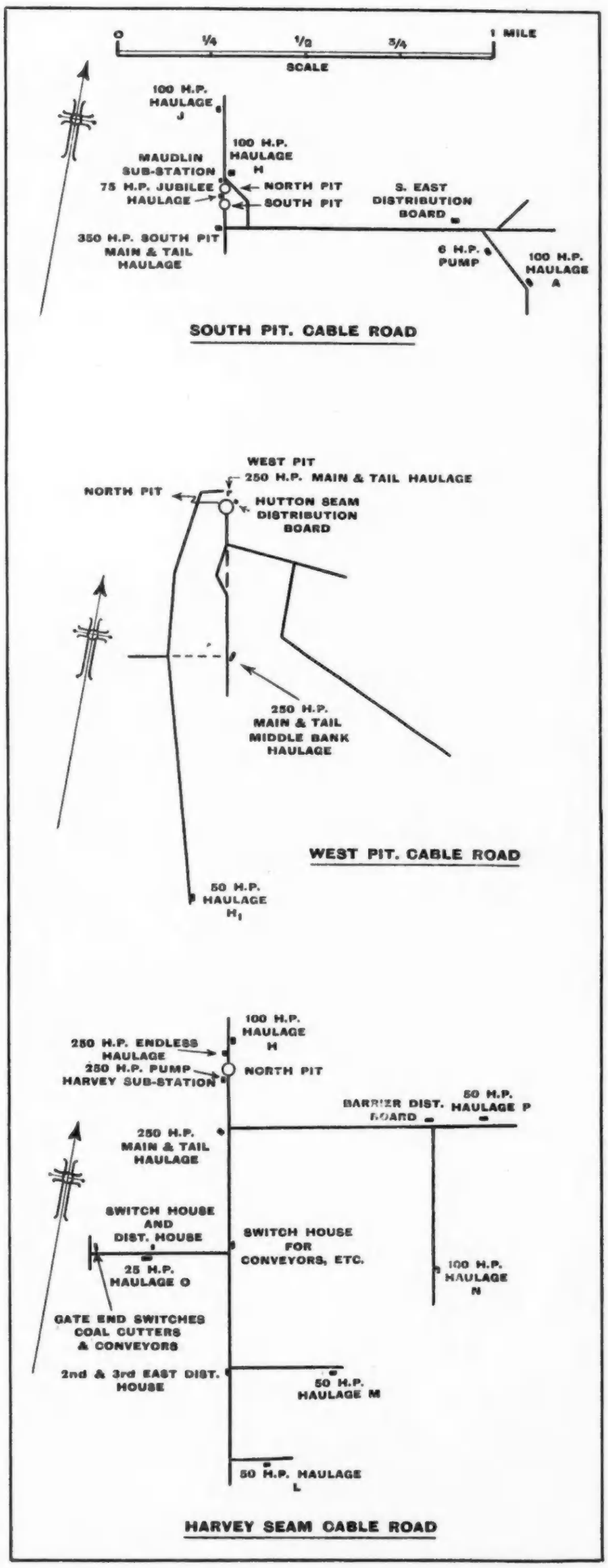


Fig. 27.—Diagram of pit cable roads.

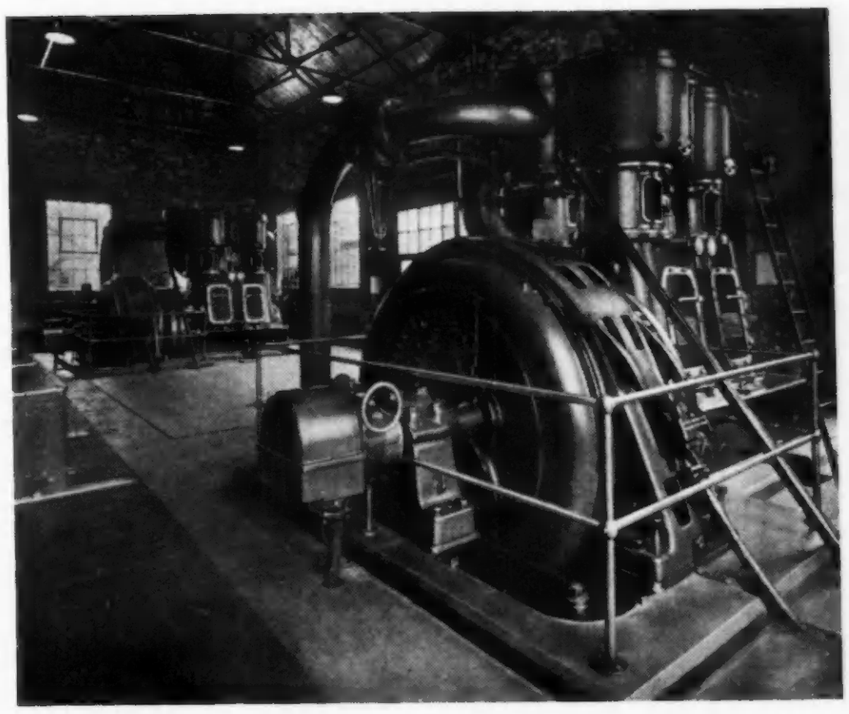


Fig. 28.—Two 585 h.p. dual frequency induction motors driving air compressors.

Fig. 29.—Two 15 h.p. 440 volt squirrel cage motors driving picking belts: the stator resistance starters are also shown.

Fig. 30.—2,750 volt flameproof oil immersed switchboard in the Harvey pit substation.

passing reference to the many motors on the surface driving workshop tools and appliances. The majority of these are driven by direct to line starters.

The three feeders which transmit power underground consist of a special form of shaft cable of .2 sq. in. cross section. The power

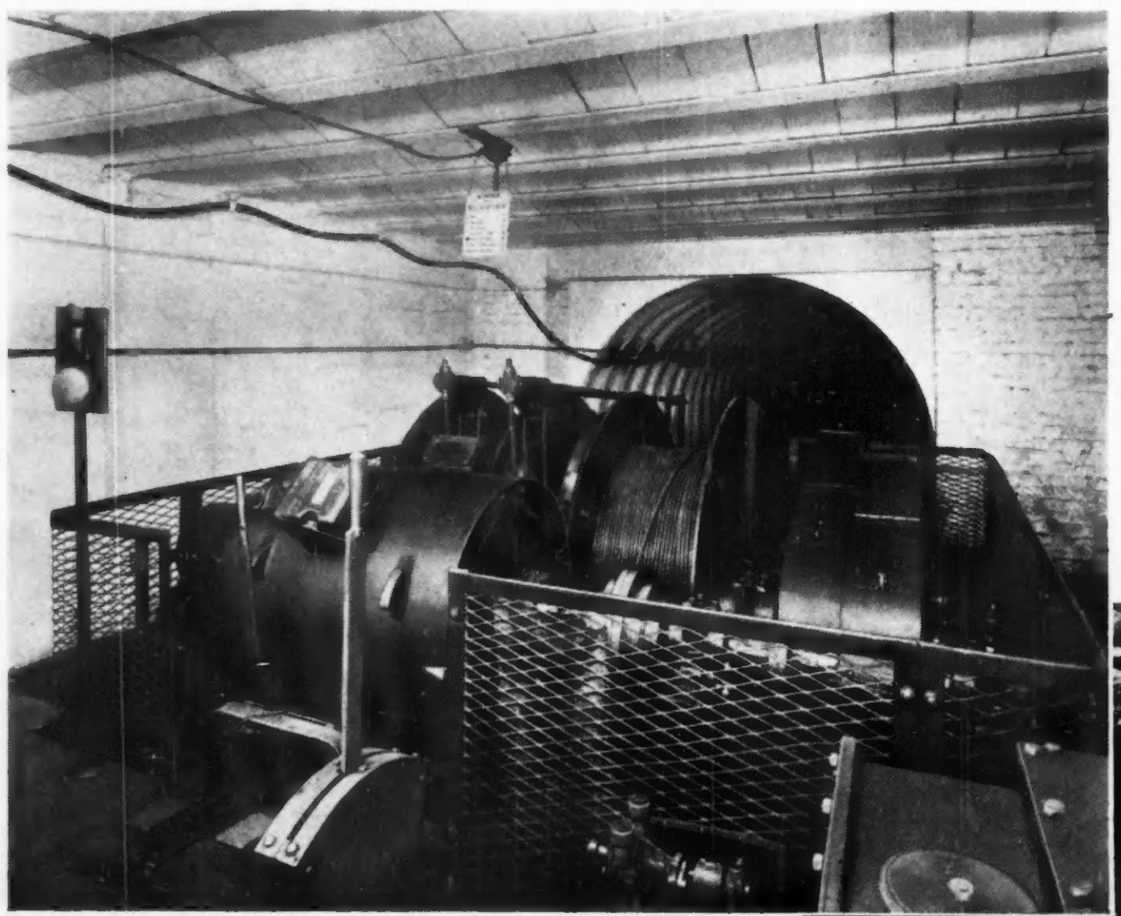


Fig. 31.—100 h.p. flameproof slipring haulage motor, 2,750 volts, 465/480 r.p.m. in the Harvey Pit.

is controlled and distributed underground from two main switchboards, each consisting of eleven pedestal oil immersed units. One is situated in the Maudlin seam and the other (fig. 30) in the Harvey pit. The two feeders brought down the shaft are taken to the board in the Maudlin pit, and the third to the board in the Harvey pit, which is also supplied by two feeders from the Maudlin substation. Apart from the control of incoming and outgoing feeder supply units, haulage and pump motor feeders are controlled by the Maudlin pit board. The board in the Harvey pit, in addition to haulage and pump motor feeders, controls also the supply to gate end boxes.

Both these switchboards are built up of standard pedestal oil immersed units embodying flameproof construction. The same type of unit is employed for local control in the various haulage and pump houses.

There are installed altogether, fourteen new electric haulage gears, the mechanical parts of which were built by Jos. Cook, Sons, & Co., Ltd.; six are of 100 h.p. capacity (one of them being shown at fig. 31) five of 50 h.p., and three of 25 h.p. The speed of the motors is 580/720 r.p.m. The 100 h.p. and 50 h.p. machines operate on the 2,750 volt supply, but power for the 25 h.p. haulages, also for pump motors, is transformed to 440 volts by auxiliary transformers situated individually in the haulage and pump houses. The 100 h.p. and 50 h.p. motors are controlled by oil immersed contactor type stator reversers and liquid controllers, for which no external cooling water is required. The 25 h.p. motors are controlled by drum type oil immersed stator starters and liquid controllers.

For the control of power to the coal

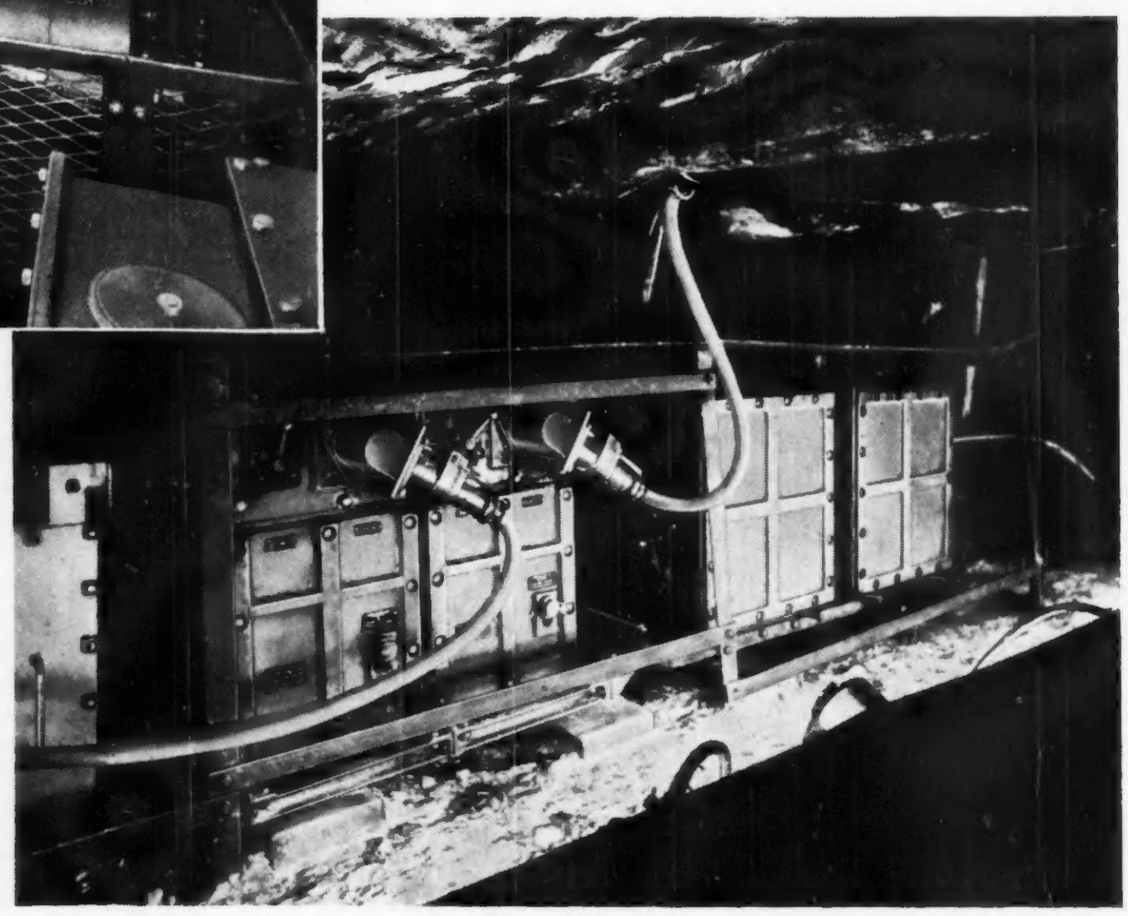


Fig. 32.—Gate-end boxes near the coal face in the Harvey pit.

face, gate end boxes, fig. 32, are employed. They embody remote controlled air break contactors with earth continuity protection.

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